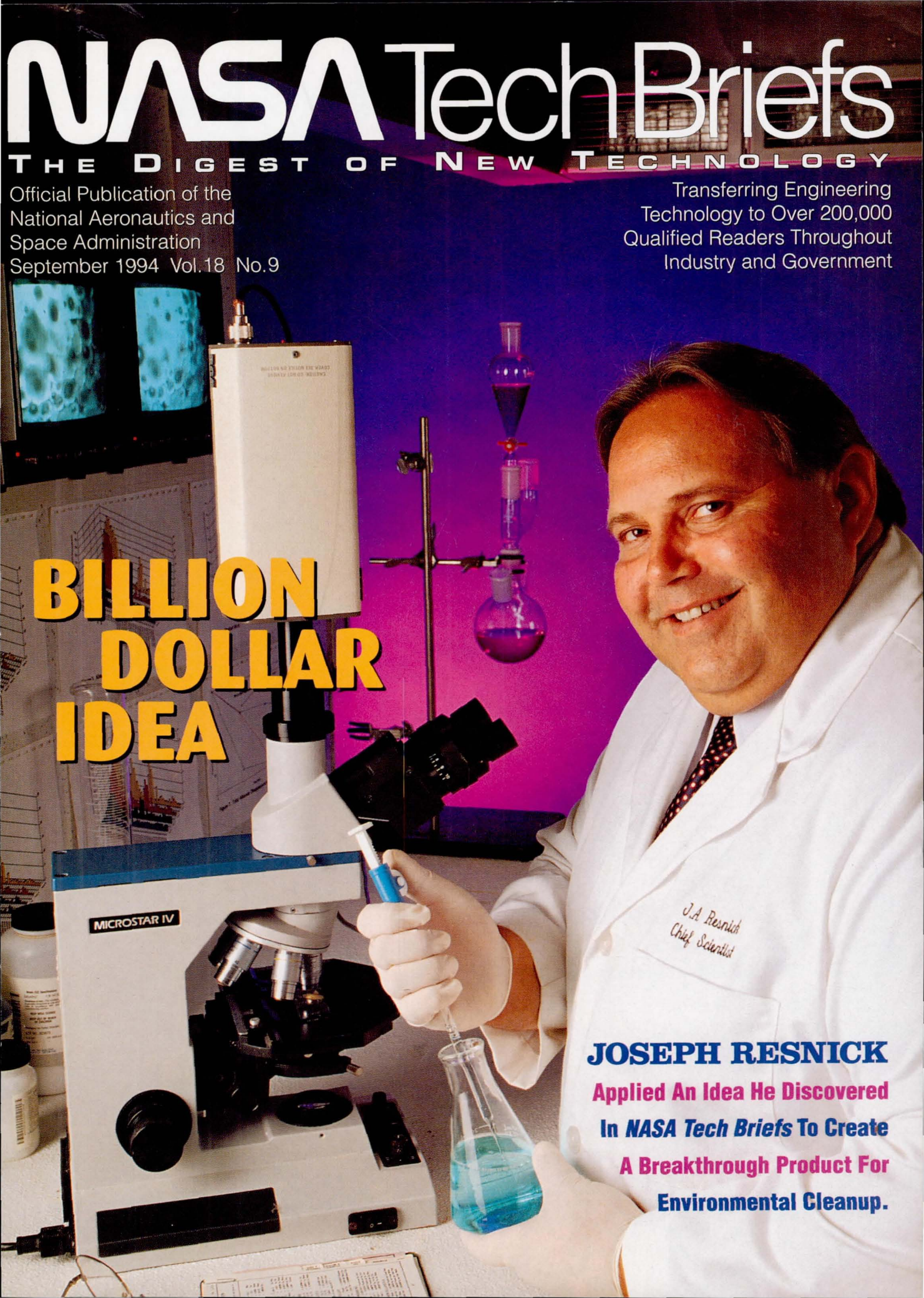
NASA Tech Briefs

THE DIGEST OF NEW TECHNOLOGY

Official Publication of the National Aeronautics and Space Administration
September 1994 Vol.18 No.9

Transferring Engineering Technology to Over 200,000 Qualified Readers Throughout Industry and Government

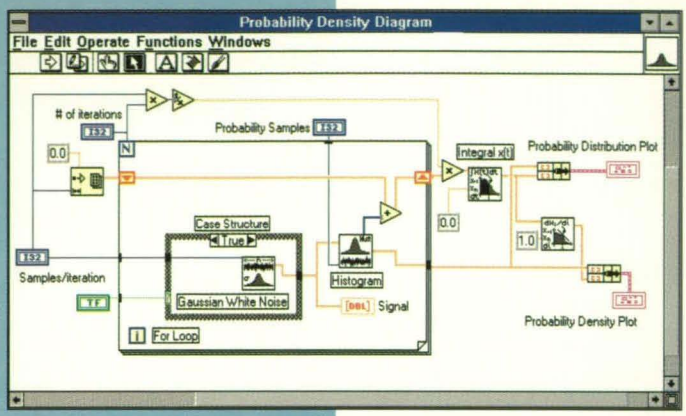


BILLION DOLLAR IDEA

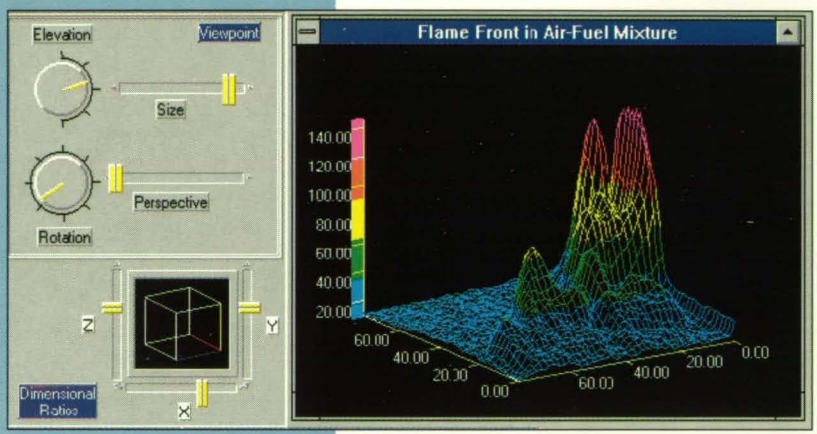
JOSEPH RESNICK

Applied An Idea He Discovered In *NASA Tech Briefs* To Create A Breakthrough Product For Environmental Cleanup.

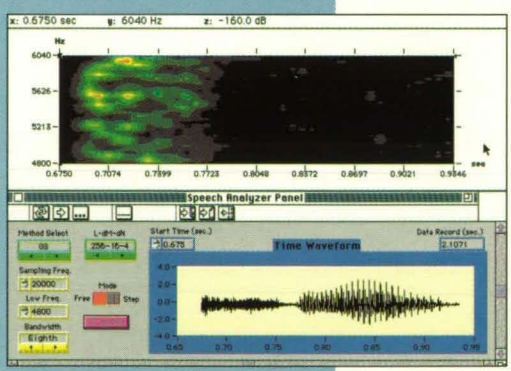
Draw Your Complete Analysis Solution
with LabVIEW® Graphical Programming



LabVIEW is a complete graphical programming language.



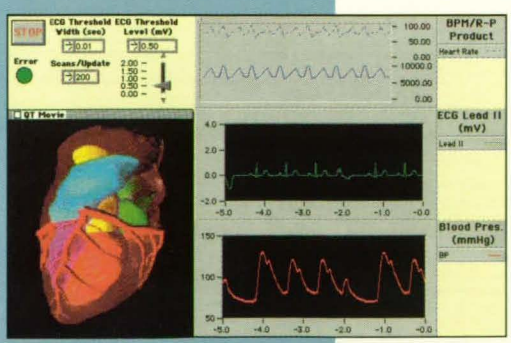
Surface plot of a flame front using LabVIEW and the SurfaceView toolkit.



Data courtesy of NIH.

Gabor Spectrogram
National Instruments

The Gabor Spectrogram displays a portion of the sentence "I take two people out for breakfast," computed and displayed with LabVIEW.



EKG signal and QuickTime heart video using LabVIEW.

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Quickly develop programs for analysis, simulation, and algorithm development with the complete graphical programming language found in LabVIEW. It is more than a math calculator. LabVIEW has graphical constructs for While Loops, For Loops, and Case structures.

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- JTFA

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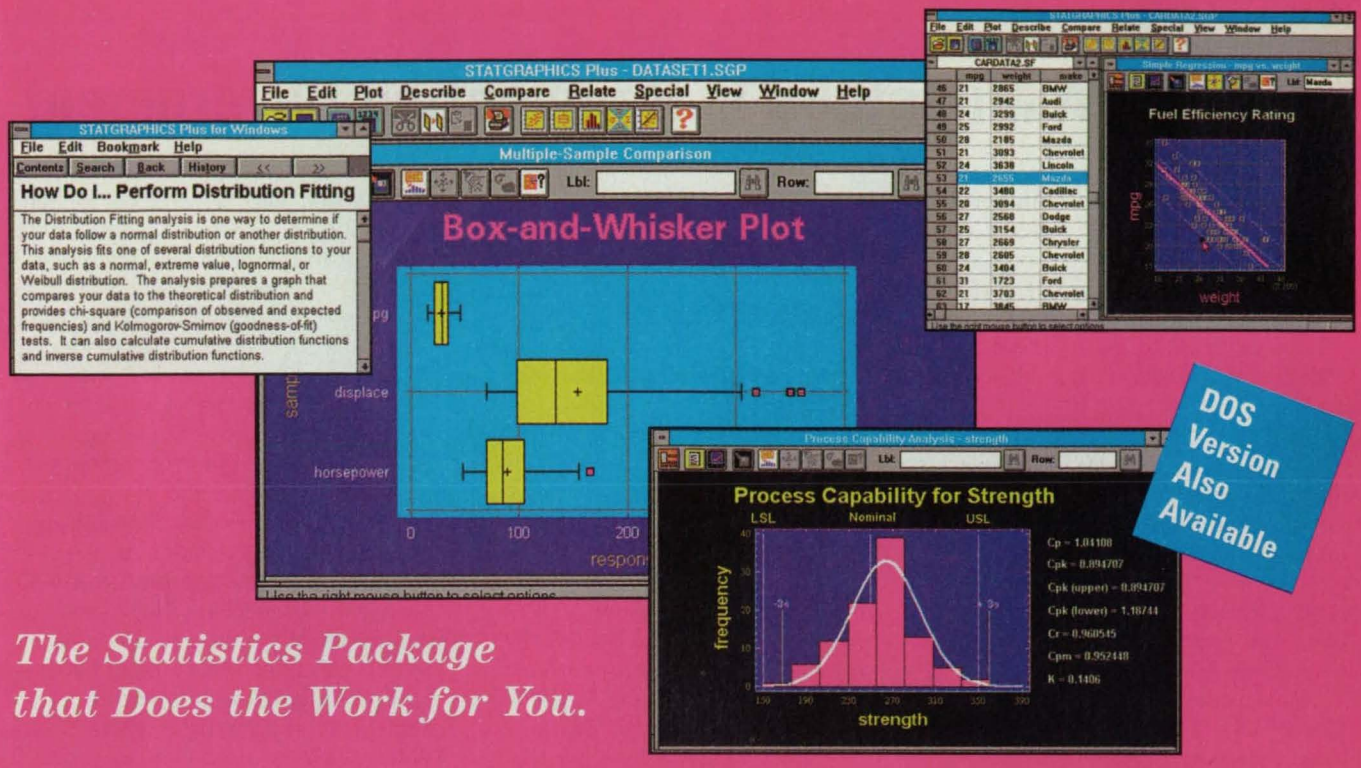

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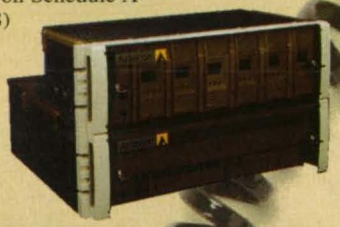

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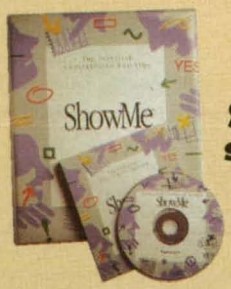

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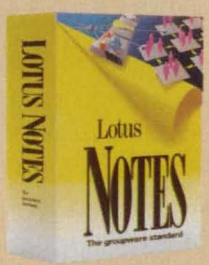

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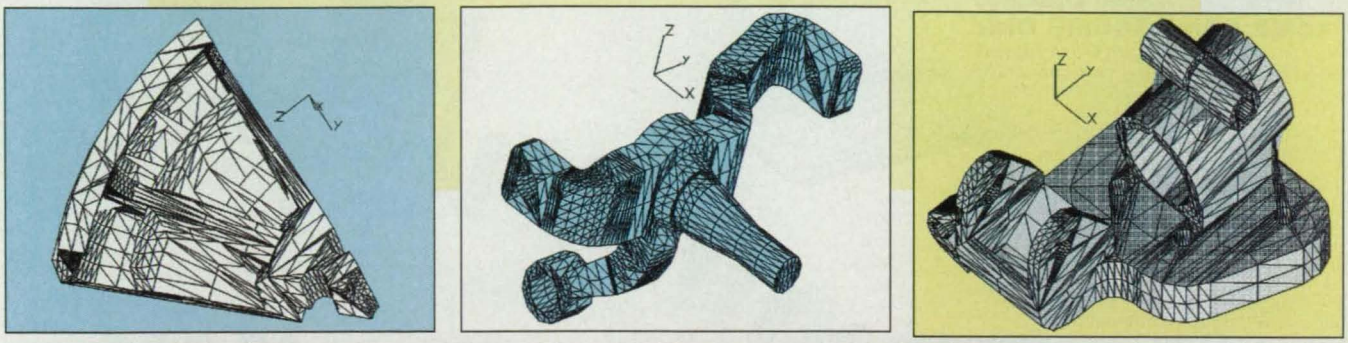

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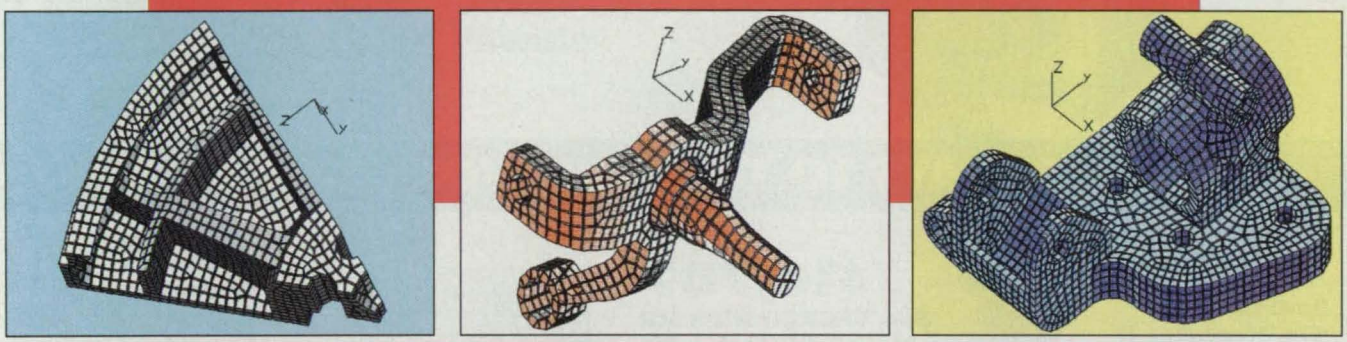

(Algor brick element models above shown with an 85% shrink-element factor.)

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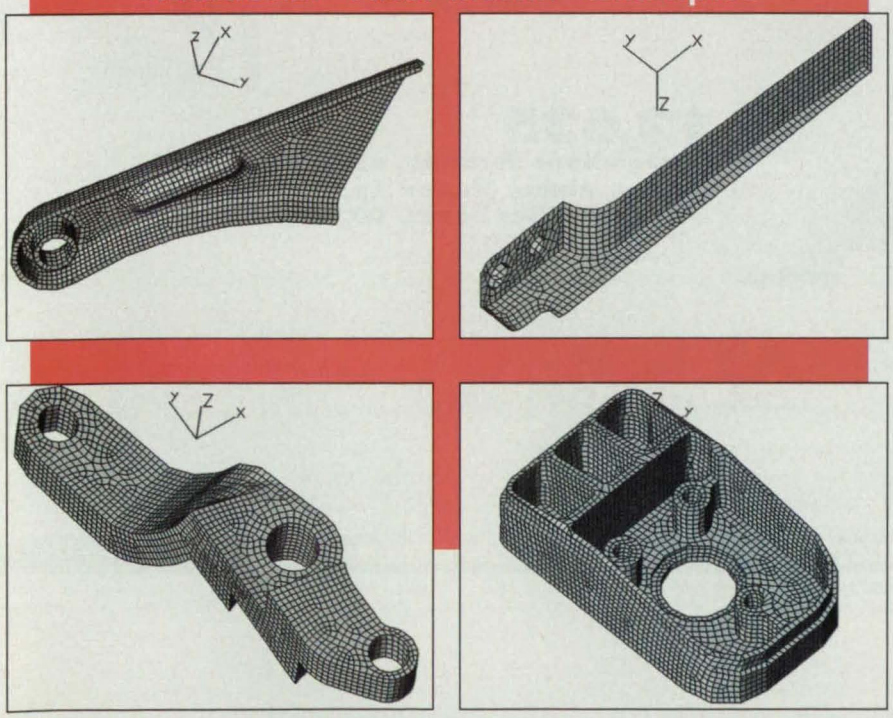
Additional "After Merlin" Examples



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Contents *(continued)*

On the cover:

Inventor Joseph Resnick employed microencapsulation techniques he found in NASA Tech Briefs *to design an innovative bioremediation delivery system that is cleaning up oil spills around the world. Manufactured by Petrol Rem Inc., the system comprises beeswax microspheres filled with petroleum-eating microbes that can be sprayed over the spill site with no risk to the surrounding ecosystem. Turn to Mission Accomplished on page 26.*

Photo: Alan J. King

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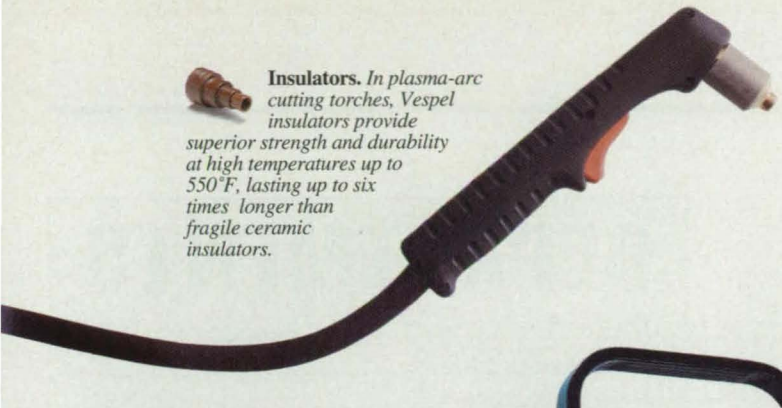

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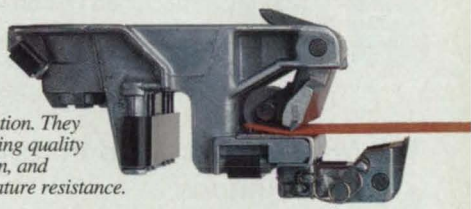

Wear Strips. *In textile equipment, Vespel tenter frame clip wear strips reduce costs by eliminating the need for lubrication. They also improve textile manufacturing quality by eliminating oil contamination, and provide good wear and temperature resistance.*

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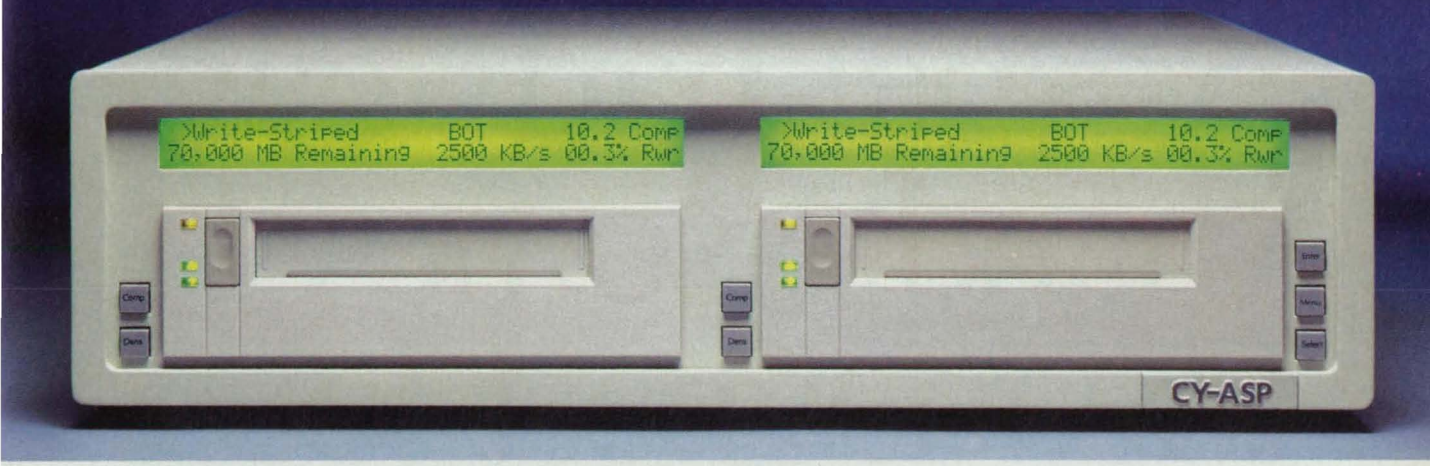

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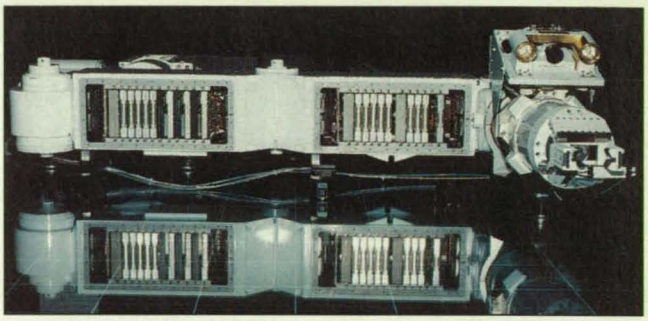

A circuit packaging system developed at Goddard Space Flight Center houses and connects control circuitry mounted on the shoulder, upper section, and lower section of a seven-degree-of-freedom robot arm. The design minimizes the number of wires between sections and prevents the wire volume from reducing the robot arm's dexterity. See the tech brief on page 70.

Photo courtesy Goddard Space Flight Center

(continued on page 10)

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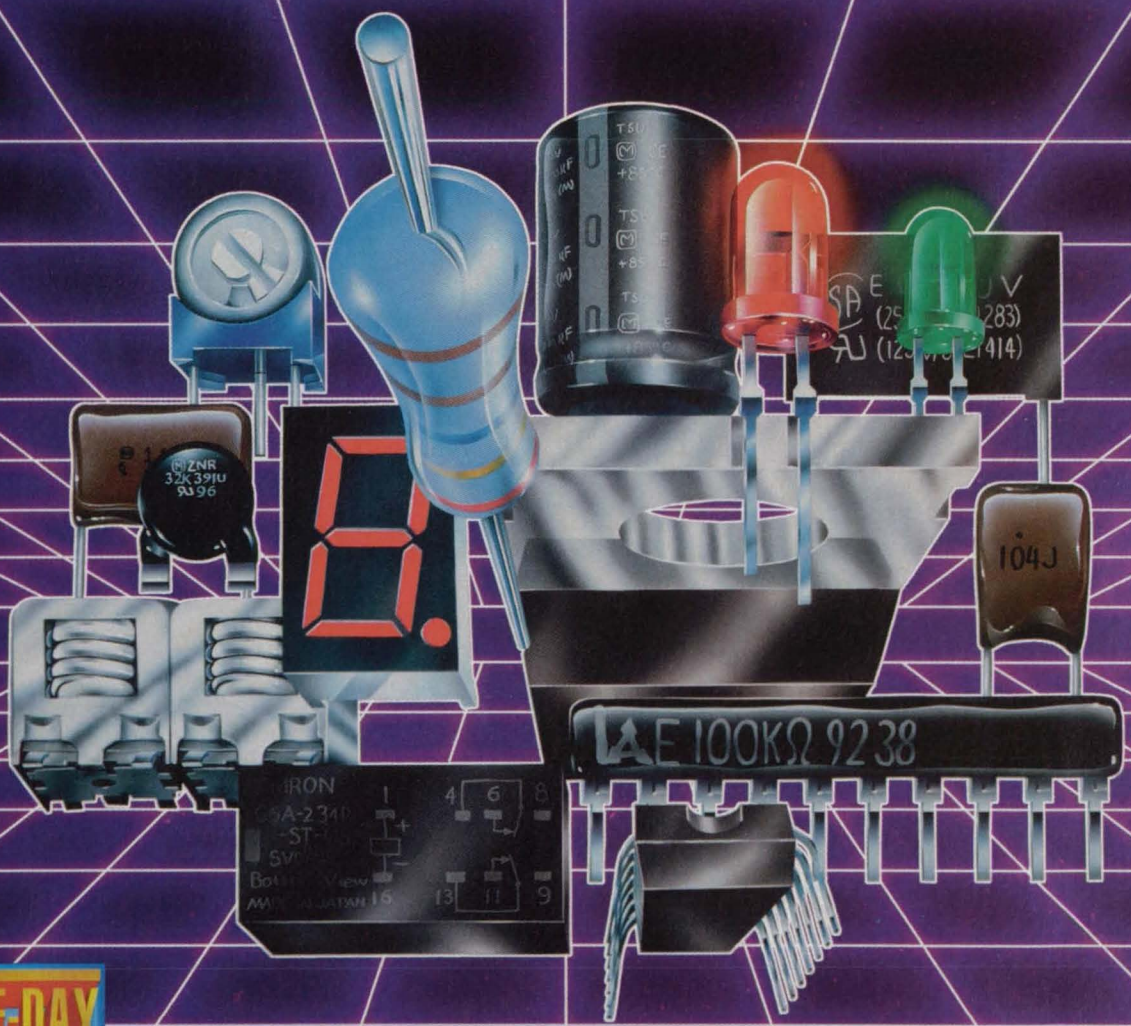

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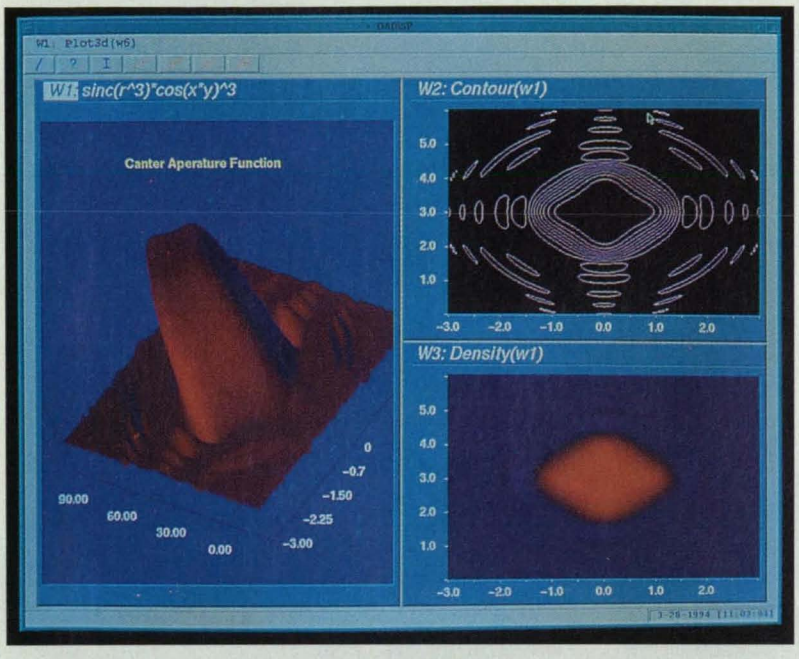

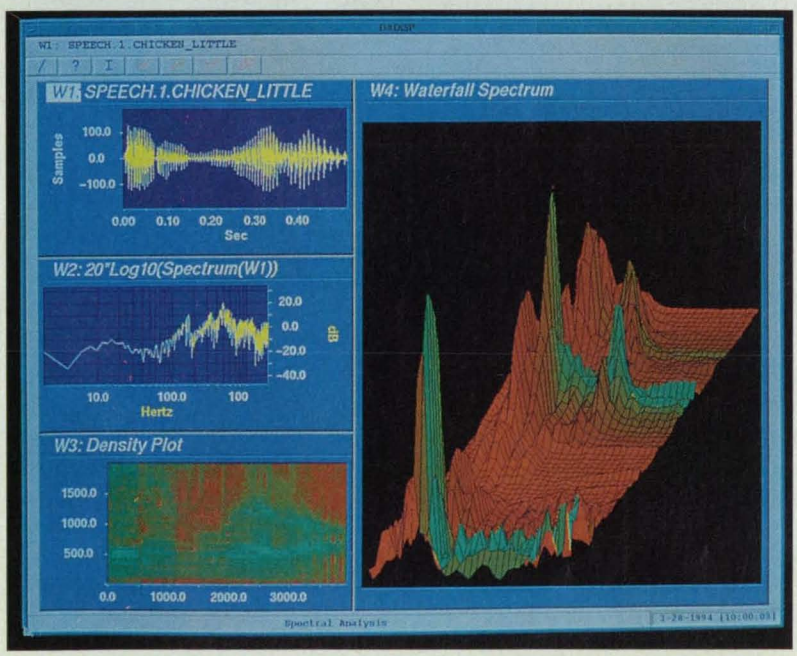

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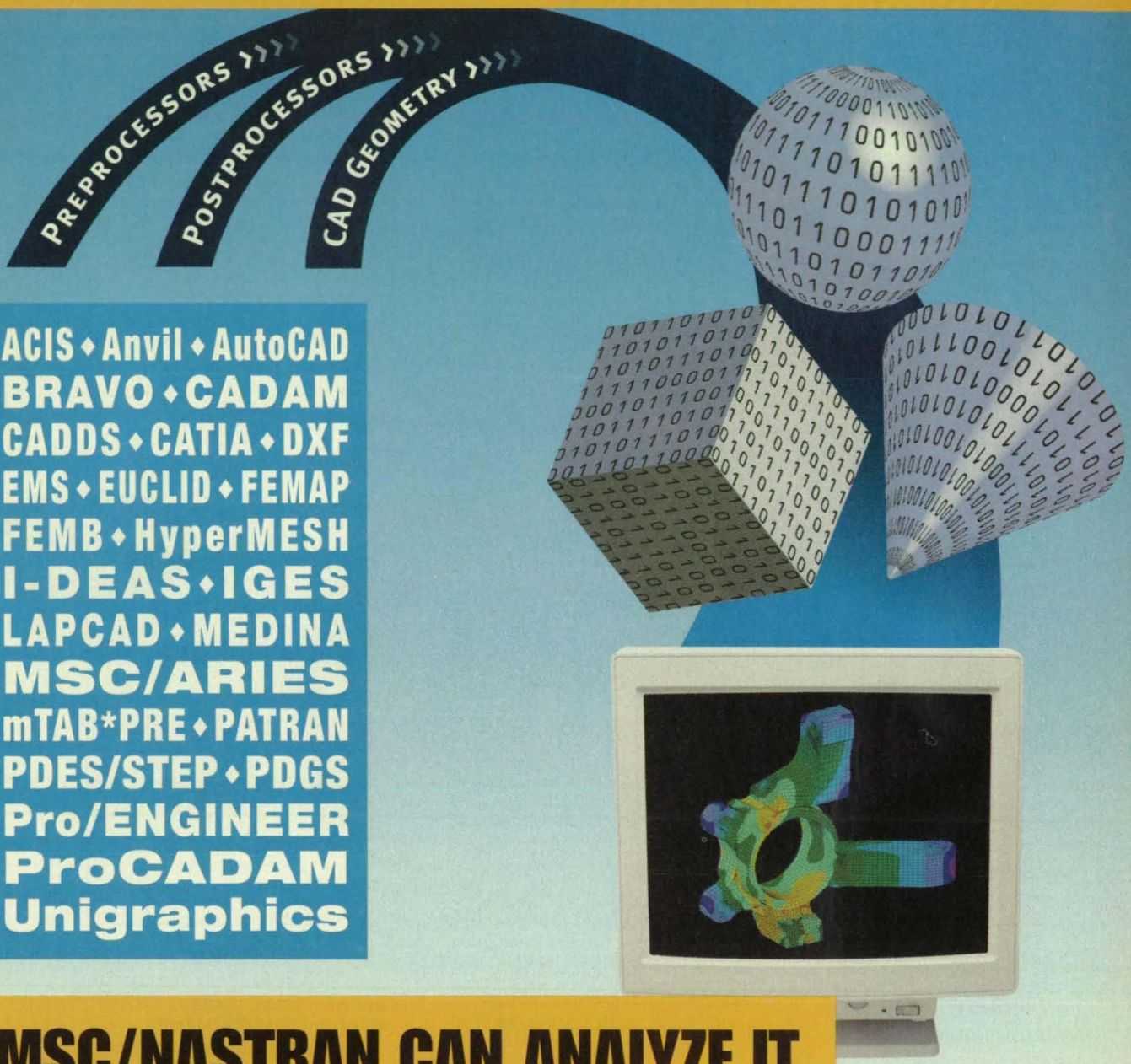

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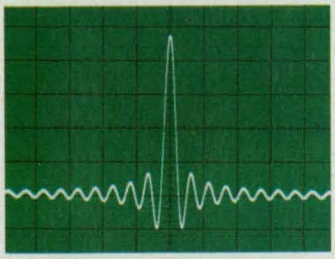
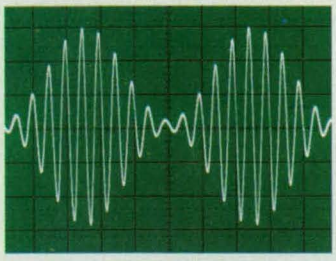


A built-in 12-bit, 40 MSample/sec, 16K deep arbitrary waveform generator easily handles your custom waveform needs.



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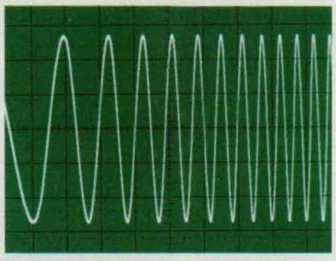

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NOTEBOOK

Bill Schnirring, *President/CEO*

A Milestone In Reinventing Government

You have the 100th commercial issue of *NASA Tech Briefs* in your hands. As many of you know, *NTB* is published through a unique government-industry partnership that began ten years ago. I'd like to share with you part of the editorial I wrote in the first commercial issue in March, 1985:

"Thomas Hobson was the 17th century English Liveryman who gave his customers the choice of renting any horse they wanted as long as it was the horse nearest to the door. Hence the term "Hobson's choice"...no choice at all. Essentially, this was NASA's position as it sought to extend the dissemination of NASA Tech Briefs *while cutting costs.*

The recommendations of the President's Commission on Cost Control, better known as the Grace Commission, underscored the problem and reinforced NASA's position: smack on the horns of a dilemma.

One of the commission's cost-cutting suggestions was to charge for subscriptions to appropriate government publications... among which was NASA Tech Briefs. *When NASA surveyed you, the reader, projections showed that converting* NASA Tech Briefs *to paid subscriptions would decimate the circulation.*

While NASA was and is in favor of cutting costs, one of Congress' original mandates to NASA was the widest possible dissemination of information and technology gained in the space exploration process. NASA Tech Briefs *has been the primary medium for this dissemination, called technology transfer. Clearly, charting a course of paid subscriptions to* NASA Tech Briefs *would be inconsistent with NASA's charter.*

You're holding the answer to the problem. It's the new NASA Tech Briefs*...a joint venture between NASA and Associated Business Publications. This is the first periodical partnership, if you will, between a government agency and a private sector publishing firm.*

In the past there has been an OMB-imposed cap of 75,000 on the NASA Tech Briefs *mailing list, which has resulted in a waiting list that has reached as high as 12,000. I'm delighted to be able to doff that cap. Now all US citizens qualified to make use of the technology described in* NTB *are entitled to free subscriptions. Several more benefits will result from our joint endeavor, not the least of which will be a $2,000,000 plus savings over the next five years."*

Well, we hit the savings target...and much more. We've saved NASA more than $12 million in printing, paper, and postage over the past decade, and have been the fastest-growing design engineering magazine in the 1990s. Our circulation has grown 174%, to over 205,000 subscribers and some 500,000 readers every month. This makes *NASA Tech Briefs* one of the world's largest engineering magazines, and the largest in the US. We also have increased the frequency of publication from quarterly to monthly, and have doubled the number of tech briefs published annually.

What we didn't know when we entered into the agreement with NASA was why we, a small publishing company, were chosen. After all, McGraw Hill, Penton, Cahners, and other giants of the business-to-business publishing world attended the pre-proposers conference. We've since found out why we were offered the opportunity...we were the only proposers.

We could speculate all day as to why no one else proposed. The fact that NASA wasn't going to pay any money might have factored into the equation, but so might any number of other things. The team that NASA had evaluating the venture gave us less than a 50-50 chance of succeeding. They weren't all that far off. We overcame a number of serious difficulties, selling other publications which enabled us to finance *NASA Tech Briefs* through those difficult times. When NASA and we entered into this unprecedented partnership, there were a number of other government publications very similar to *NTB* (as it was then). *NASA Tech Briefs* is not just the sole survivor...it is a vibrant success. And I can say that because I have it on excellent authority... your Feedback comments. Please keep them coming; I can't begin to tell you how much we appreciate them.

NASA and its Office of Advanced Concepts and Technology have a new Agenda For Change that stresses building more partnerships with industry in the coming months and years. We're looking forward to working with NASA to continue reinventing government and pioneering innovative ways of serving industry and saving taxpayer dollars. ❑

FOLLOWING ARE EXCERPTS OF REMARKS BY CONGRESSMAN XAVIER BECERRA OF CALIFORNIA, AS APPEARED IN THE AUGUST 5, 1994 EDITION OF THE *CONGRESSIONAL RECORD*:

Mr. Speaker, as a member of the House Science, Space, and Technology Committee, I want to recognize Associated Business Publications and offer my congratulations on the anniversary of its ten-year partnership with NASA and the publication of its 100th issue of *NASA Tech Briefs*.

Most of us recognize that technology is the key to economic growth, creating new jobs, building new industries, and improving our standard of living. How can we encourage the development of new technologies? By building a partnership between government, industry, and academia. Fortunately, there is an excellent example of this public-private partnership taking place today that I would like to call to your attention.

Ten years ago, NASA was looking for a way to improve its ability to transfer technology to the American public and save money. Associated Business Publications answered the call. ABP and NASA joined forces to publish *NASA Tech Briefs* at no cost to the American taxpayer.

This successful joint venture between government and small business is one way in which NASA is meeting its mandate to transfer technological innovations to the American public. Over the past ten years, nearly 7500 innovations have been featured in [*NTB*'s] pages.

Translating the language of research into the speech of the marketplace, ABP was streamlining a government process long before the call for reinventing government was ever sounded. Its relationship with NASA provides a paradigm that other federal agencies should consider adopting to ensure efficiency and success in all our work. America needs more efforts like those of ABP to turn our dreams into reality.

NASA-ABP PARTNERSHIP: A MODEL OF SUCCESSFUL INNOVATION

by Daniel S. Goldin, Administrator, National Aeronautics and Space Administration

Ten years ago, an innovative and daring experiment began at NASA. Not one to find life in outer space, or to test some form of artificial gravity. Instead, it was a simple, down-to-Earth entrepreneurial venture: the privatization of a government publication, *NASA Tech Briefs*.

No one previously had attempted to have a government-funded publication printed and distributed by the private sector at no cost to the government. To do that, the privatized publication had to break the usual mold of having government literature free of any "commercials." Appropriate advertisements would pay the publishing costs.

Thanks to the visionary minds of NASA's technology transfer managers and the entrepreneurial spirit of Associated Business Publications CEO Bill Schnirring, *NASA Tech Briefs* has evolved from a fledgling black and white circular of spartan abstracts and diagrams to an eye-catching and broadly informative full-color magazine. The circulation exploded from about 75,000 subscribers quarterly to more than 200,000 monthly, with a secondary readership in the millions.

This innovative commercial partnership between NASA and Associated Business Publications has set an example for the rest of the federal establishment in technology transfer and commercialization. But, the story doesn't end here, for NASA is not just about publications and magazines, excellent as *NASA Tech Briefs* may be. It is about the technologies that commercial users find in the magazine's pages and the benefits that may be drawn from them.

NASA Tech Briefs represents just one of many ways NASA shares its wealth of intellectual and physical resources with the American people. For example, the same technology the Viking landers used to measure microorganisms in Martian soil is now part of a commercially available implantable infusion pump for diabetics. NASA software that lets us resolve fine details in images remotely sensed from space soon will permit thousands of elderly people who suffer from low vision to watch television, read, and function more normally in their immediate surroundings.

The ancillary value of NASA's aeronautics and space programs to our everyday lives on Earth is potentially immense, but we need the entrepreneurs, inventors, businesses, and other risk-takers to see this value and derive commercially viable products or services. This is the critical role that *NASA Tech Briefs* and our other technology transfer mechanisms play. They make the technology and other NASA capabilities well known, make them easily accessible, and help their infusion into the marketplace.

We've done well, but there is always room for improvement. Taking a page from the *NASA Tech Briefs* experience, we're now empowering all of our NASA scientists, engineers, and administrators to break the old molds and think in new terms. They are realizing that technology transfer and commercial application of their NASA missions-derived discoveries are as much their responsibilities as the missions themselves. This is a win-win philosophy. The more we contribute to the nation's economic health and wealth, the more willing Americans will be to invest in NASA missions.

So on its tenth anniversary, congratulations to the *NASA Tech Briefs* enterprise and those at NASA and Associated Business Publications who have made its success possible. ❑

THE WHITE HOUSE

WASHINGTON

August 5, 1994

Mr. Bill Schnirring
President
NASA Tech Briefs
Suite 921
41 East 42nd Street
New York, New York 10017

Dear Bill:

It is my pleasure to congratulate you and all those at Associated Business Publication on production of the one hundredth issue of NASA Tech Briefs and on the unique ten-year relationship that makes this magazine possible.

The collaboration between NASA and Associated Business Publication provides an important means for the transfer of information between the public and private sectors. Every day, millions of American citizens benefit from the widespread distribution of space technology.

Thanks to you, businesses and individuals across our country have learned about the fascinating and useful results of NASA research and are better prepared to meet the challenges of the twenty-first century.

I commend you for your involvement in this wonderful partnership, and I extend best wishes for continued success.

Sincerely,

Bill Clinton

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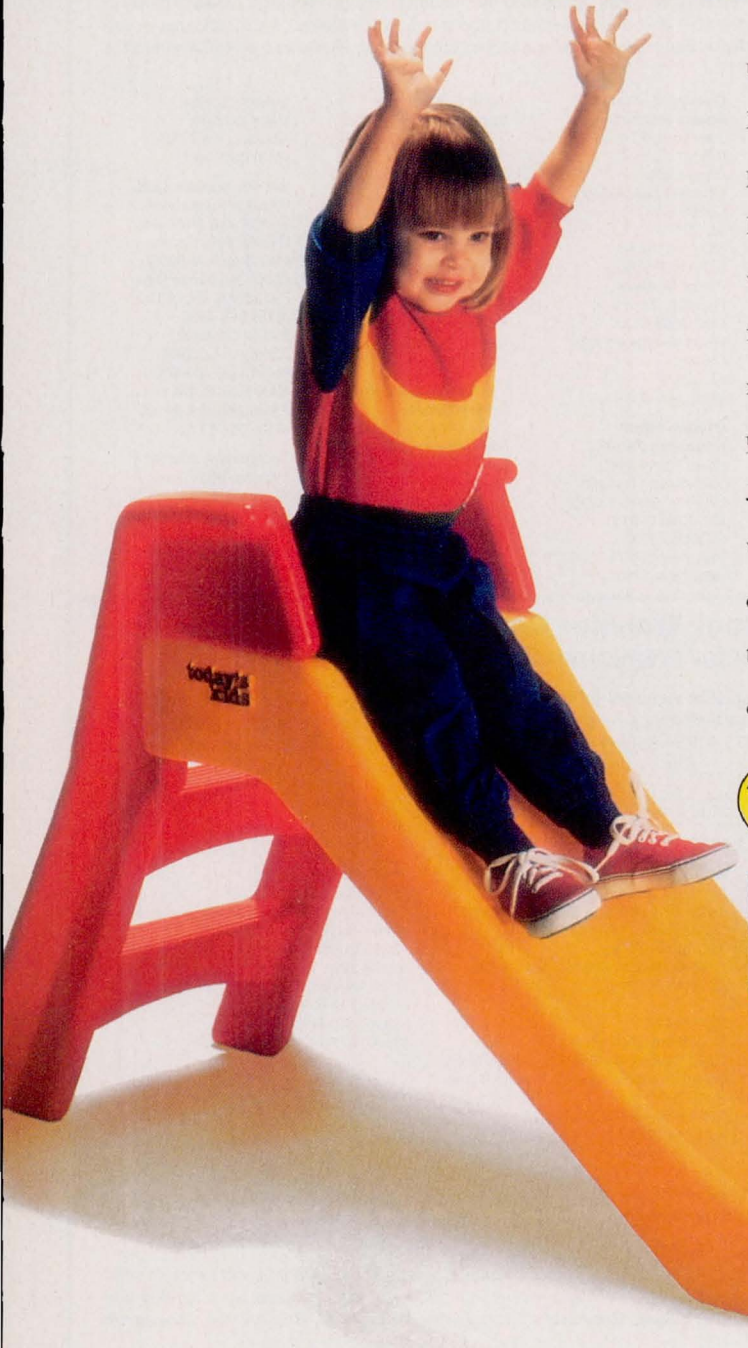

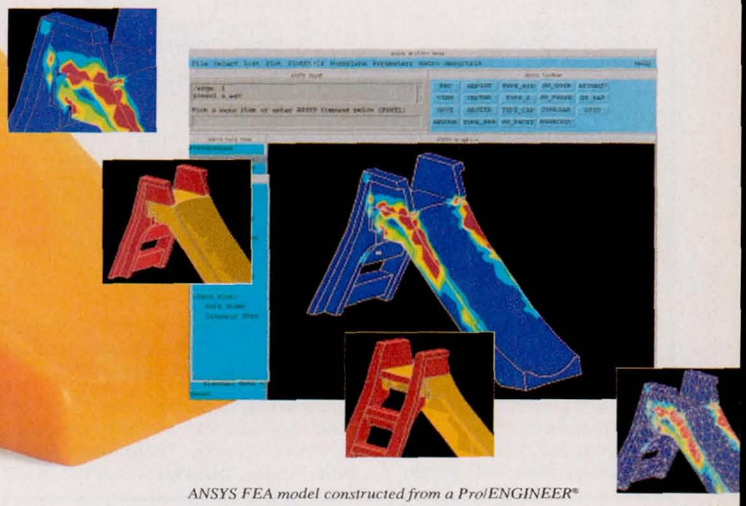

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ANSYS FEA model constructed from a Pro/ENGINEER® assembly accurately showed that large, nonlinear deflections tripled the maximum stresses in the slide handrail.

Photograph and FEA model provided courtesy of Today's Kids, Dallas and DRD Corporation, Tulsa.

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HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY TRANSFER SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low- and no-cost services provided by NASA's Technology Transfer Program. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by this Program. In fact, when all of the components of NASA's Technology Transfer Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered.

How You Can Access Technology Transfer Services At NASA Field Centers:

Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in NASA Tech Briefs, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

Lewis Research Center
Technology Utilization Officer: Anthony F. Ratajczak
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5568
Patent Counsel:
Gene E. Shook
Mail Code LE-LAW
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Cleveland, OH 44135
(216) 433-5753

John C. Stennis Space Center
Technology Transfer Officer: Richard A. Galle
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Stennis Space Center, MS 39529
(601) 688-1929

Goddard Space Flight Center
Technology Utilization Officer: Dr. George Alcorn
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Greenbelt, MD 20771
(301) 286-5810
Patent Counsel:
R. Dennis Marchant
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Greenbelt, MD 20771
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Technology Application Group
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Patent Counsel:
Dr. George F. Helfrich
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Ames Research Ctr.
Office of Commercial Technology Director:
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(415) 604-6406
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NASA Headquarters
Technology Utilization Officer: Leonard A. Ault
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(202) 358-0721
Associate General Counsel for Intellectual Property: Jack Mannix
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Washington, DC 20546
(202) 358-2424

George C. Marshall Space Flight Center
Technology Transfer Officer: Harry G. Craft Jr.
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Marshall Space Flight Center,
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(205) 544-0963
(800) 437-5186
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Marshall Space Flight Center,
AL 35812
(205) 544-0021

Dryden Flight Research Facility
Project Manager, Technology Transfer Office: Yvonne Kellogg
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(805) 258-3720

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Patent Counsel:
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Jet Propulsion Lab.
NASA Management Office
Technology Utilization Officer: Arif Husain
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Technology Utilization Mgr. for JPL:
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Pasadena, CA 91109
(818) 354-2240

How You Can Utilize **NASA's Regional Technology Transfer Centers (RTTCs)**—A nationwide network offering a broad range of technology transfer and commercialization services.

You can contact NASA's network of RTTCs for assistance in solving a specific technical problem or locating technology or markets that match your interests. The RTTCs are experienced in working with industry to define technology needs and acquire and commercialize applicable technology. User fees are charged for most services. For more information, call 1-800-472-6785 and you will be connected to the RTTC in your geographical region (or you may call or write directly to the RTTC in your region).

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FAR-WEST
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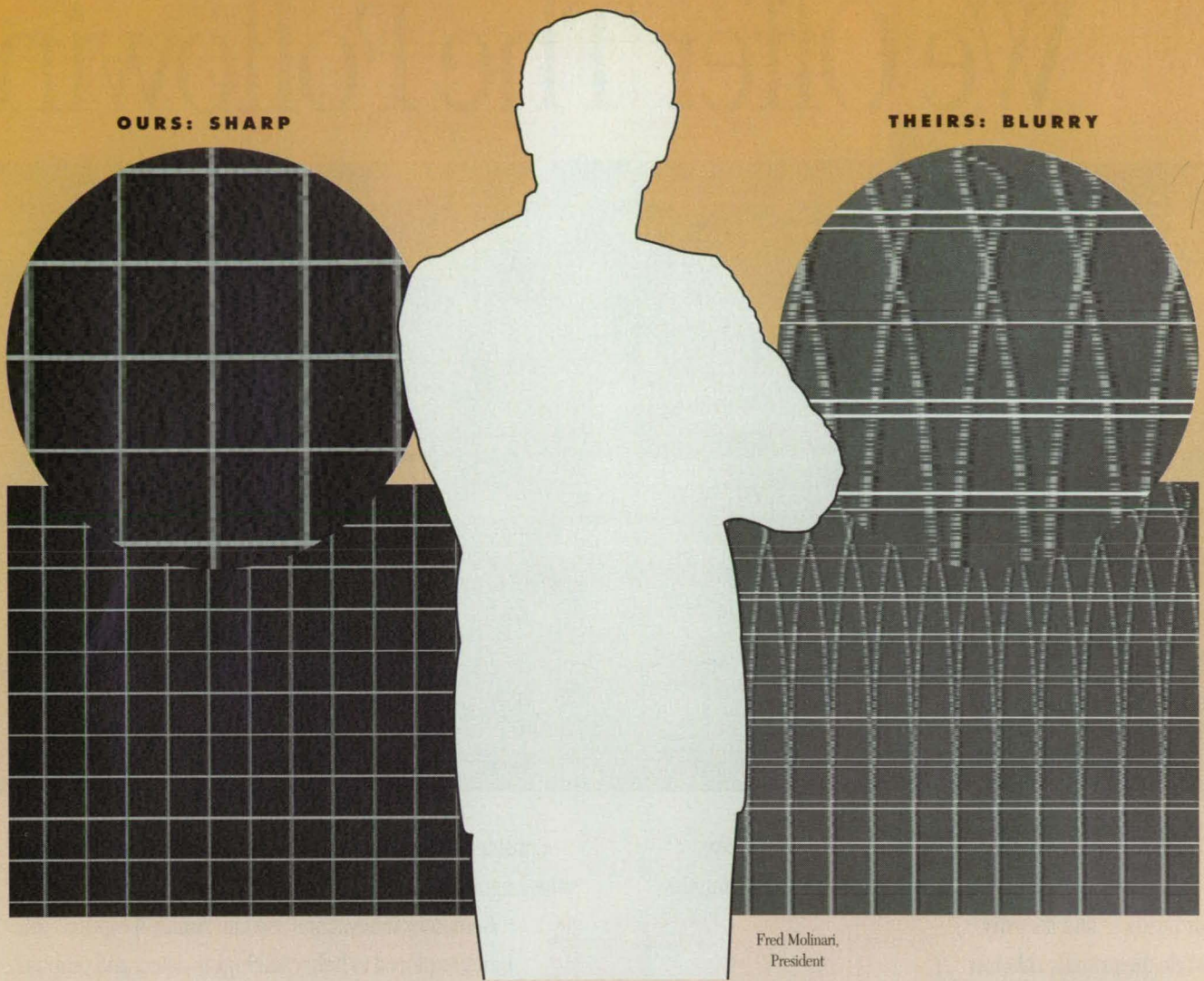
Technology Transfer Center
University of Southern California
3716 South Hope Street,
Suite 200
Los Angeles, CA 90007-4344
(213) 743-6132
(800) 642-2872 (CA only)
(800) 872-7477 (toll-free US)

If you are interested in information, applications, research, training, and services relating to satellite and aerial data for Earth resources, contact NASA's transfer point for earth observing technology: **Earth Data Analysis Center, University of New Mexico, 2500 Yale Blvd. S.E., Suite 100, Albuquerque, NM 87131-6031; Dr. Stan Morain, Director (505) 277-3622.**

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; Dr. Doris Rouse, Director, (919) 541-6980**

A Shortcut To Software: **COSMIC®**—For software developed with NASA funding, contact COSMIC, NASA's Computer Software Manage-ment and Information Center. New and updated programs are announced in the Computer Programs section. COSMIC publishes an annual software catalog. For more information call or write: COSMIC®, 382 East Broad Street, Athens, GA 30602 John A. Gibson, Director, (706) 542-3265; FAX (706) 542-4807.

If You Have a Question..**NASA Center For AeroSpace Information** can answer questions about NASA's Technology Transfer Network and its services and documents. The CASI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: NASA Center For AeroSpace Information, Technology Transfer Office, 800 Elkridge Landing Rd, Linthicum Heights, MD 21090-2934. Walter M. Heiland, Manager, (410) 859-5300, Ext. 245.



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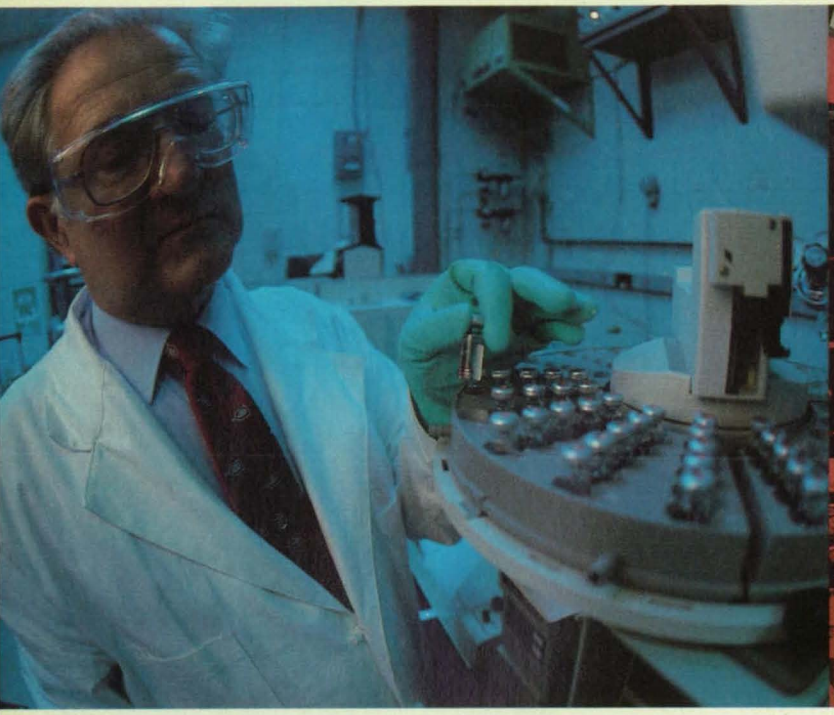

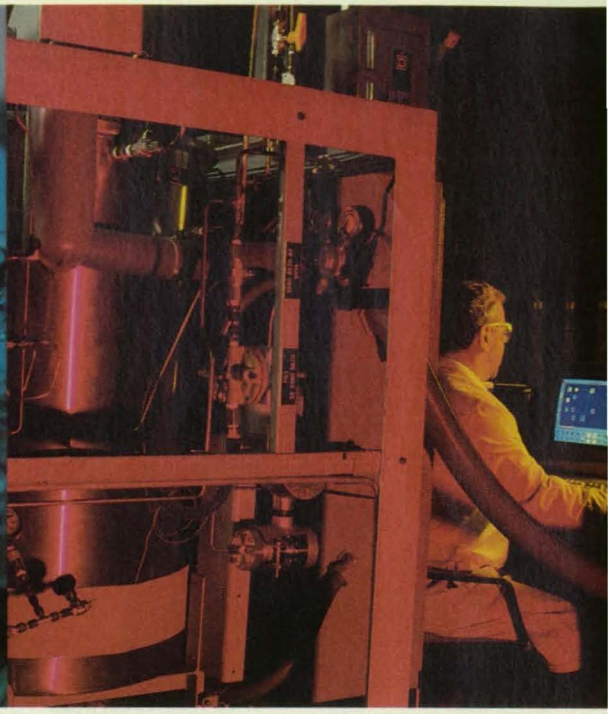

Dramatic changes in the U.S. Defense environment have opened a world of exciting and profitable new opportunities for business and industry. While the primary mission of Air Force Science and Technology continues to maintain the best Air Force in the world, a new direction is emerging – the support of a healthy economy and bolstering America's global competitiveness. By offering a wealth of research and technology, this new open-door policy can provide countless new opportunities for your company.

Our sign is out...we're open for your business!

Technology Transfer – Open Access for Business

Our new Air Force mission encourages the offering of technology developed through Air Force facilities for commercial applications. We call it Technology Transfer.

Through these transfers, the Air Force is making its research laboratories, test centers and depots available to business and industry like never before, creating partnerships in "dual-use" technologies. Considered the most promising of all the research endeavors underway by the Air Force, dual-use technologies both meet the needs of our military forces and offer significant potential for commercial application.

Consider just a few of these Technology Transfer Partnerships ongoing today:

- Computer innovations used in "Smart Weapons" are being explored to help radiologists detect and pinpoint breast cancer much earlier than before.
- A type of Phased Array radar system is being placed on school buses to warn drivers that children are close by.
- Self-lubrication ball bearings – used in the space shuttle – are being looked at for use in several commercial manufacturing situations.
- Imagine a pedestrian footbridge that never wears out, never rusts, never needs painting and requires virtually no maintenance. Now being tested, this bridge is so lightweight it can be lifted into place by a few workers using a small hoist.

Technology from war-related research is being utilized in the fields of medicine, education and countless other peacetime applications.

There are many other success stories where dual-use technologies have been quickly and effectively transferred from Air Force Laboratories to the commercial marketplace. Many more opportunities are waiting for you. Can your organization get involved in Technology Transfer? The answer is Yes! We work through simple agreements with

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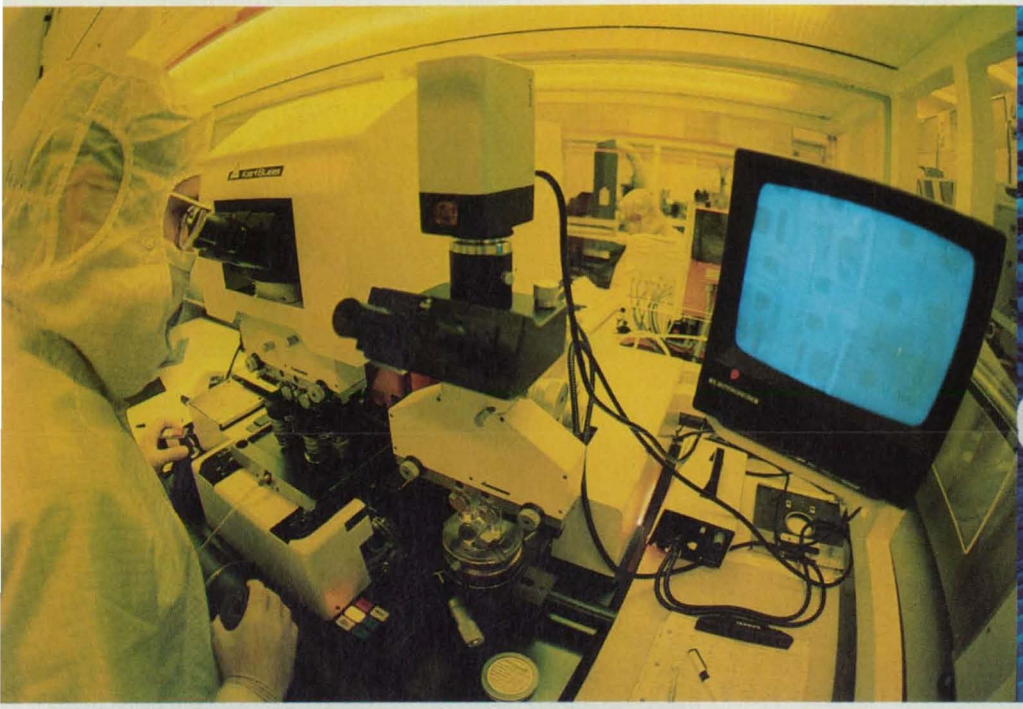

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Air Force Laboratories create technology solutions that are fully transferable to the commercial marketplace. Many are already on the shelf and waiting to be used.

These laboratories also have a reputation for solving some very tough technical problems. Laboratory expertise is available in a broad array of technical areas, including:

- Electronics
- Communications
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- Environmental Sciences
- Industrial Design
- Public Safety
- Engines and Power Sources
- Health Care
- Transportation
- Energy
- Materials and Structures
- Human Factors
- Manufacturing

Products, Solutions, Partnering

Technology Transfer offers a winning combination of scientific expertise, unique facilities and highly sophisticated equipment, all focused on helping your business create new products, solve tough technical problems and become more competitive in the global marketplace through partnering. Already, companies from the fields of automobile design, aviation and medical research are lining up to take advantage of the awesome capabilities that the Air Force Laboratories have to offer. To enhance your company's position in the new global arena, give us a call at our *"Tech Connect"* Hotline and discover how we can bring new signs of life to your project.

Infrared night vision research may someday aid the visually impaired.

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Over the last decade, we have received tens of thousands of Feedback comments and letters from you, the readers, detailing how you have reapplied ideas from the magazine to solve engineering problems, develop new or better products, and improve everyday life. Some applications have led to entirely new businesses, many others to process innovations that saved time or money. Though no retrospective could ever capture the breadth and diversity of those applications, we would like to share with you this month, as we celebrate our 100th issue published at no cost to taxpayers, a few examples of how this unique, proactive forum has yielded practical benefits and helped accomplish NASA's technology transfer mission.

Six years ago, inventor Joseph Resnick saw the need for a way to deliver petroleum-eating microbes to oil spills without endangering the organisms or compounding the environmental hazard.

Then, he got a lead: microspheres like those described in *NASA Tech Briefs* could protect and carry the biodegrading organisms to the spill site.

After years of R&D, the result is a novel microencapsulation bioremediation delivery system manufactured by Petrol Rem Inc., a subsidiary of Biocontrol Technologies Inc., Pittsburgh, PA. Known as the Petroleum Remediation Product (PRP), the system has generated multi-year contracts worldwide worth more than a billion dollars.

The need for effective oil-spill removal techniques has become more pressing with each new environmental tragedy, including the massive oil slicks in the post-war Persian Gulf and the 1989 Exxon *Valdez* oil spill in Alaska's Prince William Sound. The problem with available bioremediation methods had been that the organisms—highly sensitive to conditions such as salinity, pH, and radiation—either couldn't survive the journey to the site or, once there, didn't live long enough to do their job.

Resnick's solution was sparked by a *NASA Tech Briefs* article by Dr. John Vanderhoff, then at Marshall Space Flight Center, describing a rotary reactor to make microballoons. Vanderhoff's tech brief and subsequent briefs by Dale Kornfeld at Marshall and Taylor Wang at Jet Propulsion Laboratory led Resnick to speculate that microcapsules might present the ideal delivery system for bioremediation.

Resnick, now Petrol Rem's chief engineer, has met his share of thorny problems. With nine US patents and eleven patents pending, he approaches each inventing challenge from a varied background in medicine, public health management, and environmental engineering. Among his many inventions are a container tamper detection device, a water pollution alarm system, an artificial voice box that can be implanted in a user's tooth, and a device that helps the deaf and hearing-impaired to speak more clearly.

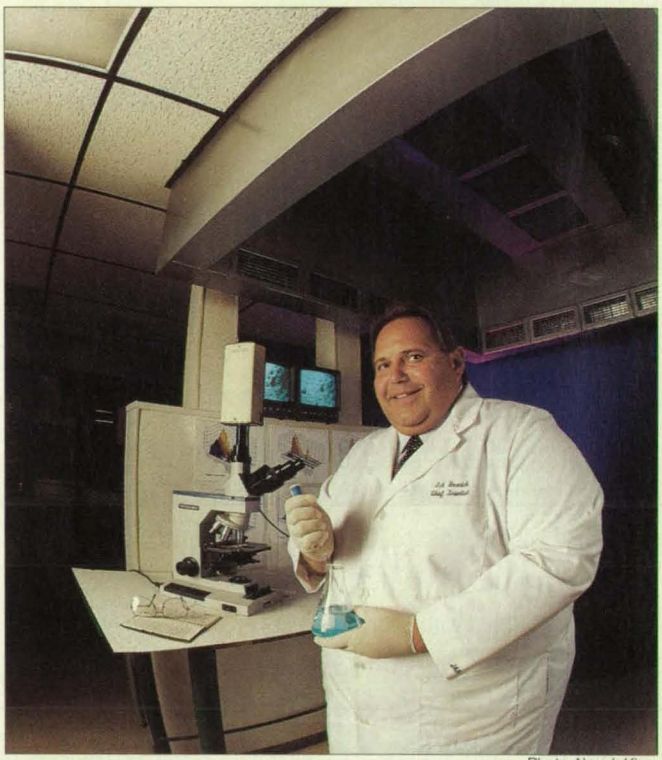

Photo Alan J. King

Inventor Joseph Resnick's innovative bioremediation delivery system for petroleum spills employs NASA-developed microencapsulation technology.

Resnick realized he needed three things for his bioremediation system: organisms that could both biodegrade petroleum and survive the encapsulation process, a material out of which to make the microspheres, and a machine to manufacture them.

Research revealed the best microbes to be pseudomonads, a type of bacteria, and several strains of *Candida* yeasts, the largest of the fat eaters. These organisms eat hydrocarbons, the organic fats within gasoline or petroleum. However, they lack an osmosis control mechanism and in aquatic environments will absorb water until they burst.

This is where the microspheres come in. By making them out of beeswax, Resnick solved several problems. Beeswax is both hydrophobic and oleophilic, so while it is impervious to water, it clings to oil and permits passage of complex hydrocarbon molecules through the walls

and into the microspheres.

"When I encapsulate the organisms, I'm able to provide a barrier between the spill and the medium into which it has spilled," explained Resnick. "For example, in a fresh or salt water spill, if you put PRP on the top of the spill, it migrates to the area between the spill and the water, protecting indigenous ecotypes from exposure to the spill while protecting the bacteria and yeast from the water." When PRP has finished degrading the oil spill, the beeswax can be used as a food source by local organisms.

Resnick next needed to configure an apparatus that would allow him to put the beeswax and these living organisms through an orifice without putting the organisms in jeopardy. "I combined what I had learned from all of the tech briefs," he recalled. "The first prototype, built in my garage, incorporated a pressure cooker bought for eight dollars at a garage sale and two syringes, one fitted inside the other."

Biocontrol Technologies learned of Resnick's invention and proposed a joint venture; Petrol Rem was born. The parent company financed the construction of a full-scale prototype and then a gigantic production model.

The capsules range in size from .25 to 500 micrometers. "It looks like a real fine powder, but if you put it under a microscope, you can see they're little balls with a liquid center," described Resnick.

The next step was testing by the Environmental Protection Agency (EPA) and the National Environmental Technology Applications Corporation (NETAC), a nonprofit corporation formed in 1988 through a cooperative agreement between the EPA and the University of Pittsburgh to accelerate the development, application, and commercialization of environmental technologies. NETAC's detailed study of PRP, conducted in a specially-constructed tank to avoid introducing oil into a natural environment, found it "capable of significantly accelerating the natural rate of diesel oil degradation in near-environmental conditions."

Not only does the system degrade the spill, but it prevents oil migration and the formation of tar balls. Without it, wave action can whip up the spill, separating the lighter molecules in the oil from the very dense ones. "These denser molecules comprise the material that washes up on the beach, the most lethal part of the spill that chokes out oxygen and kills indigenous wildlife," Resnick said. "Our material eats it like popcorn."

Since the NETAC study, Petrol Rem has signed a number of commercial contracts with major utilities, including Maryland Power & Light, and several oil companies in South America and elsewhere. A recent multi-year, billion-dollar contract with Mexico will supply each of the country's 22 on-land oil refineries with up to 1.5 tons of PRP per week. "We used it on a lake in Cuernavaca that was completely covered with oil," reported Resnick. "After application with two large sprayers, the lake was clean in three days."

PRP is the only biological product permitted for use in the Chesapeake Bay. Stored at room temperature in 100-pound drums, the material retains 100% efficiency for over three years, according to Resnick.

"When I look back at the development," he said, "all I really did was take what was already out there, reshape it to do what we, the human race, want it to do for a little while and then, when it's done, disappear back into the environment."

For more information about the technology described in this article, write in number 760.

Sandra Rossi had no reason to feel endangered as she prepared to bathe in a cool African river on a humid day in March 1993. The St. Charles, Missouri native had been working as an instructor to the children of American naturalists in central Zaire. With no running water available in their remote jungle camp, everyone bathed in the nearby Epulu river, used for decades in the belief that the river was too shallow and the currents too swift for dangerous creatures to reside there.

Rossi was accompanied to the river bank by two children and Ken Cochrane, a research assistant. Cochrane and the children had returned to shore after washing. Suddenly, Rossi, alone in the water as she rinsed her hair, was attacked from behind by an enormous Nile crocodile, a man-eating species previously unknown in the region.

The reptile grabbed Rossi by the left arm below the elbow and pulled her beneath the water. Rushing to her aid, Cochrane tried to free Rossi from the crocodile's jaws, but the creature repeatedly dragged her under. After several minutes of fighting they were able

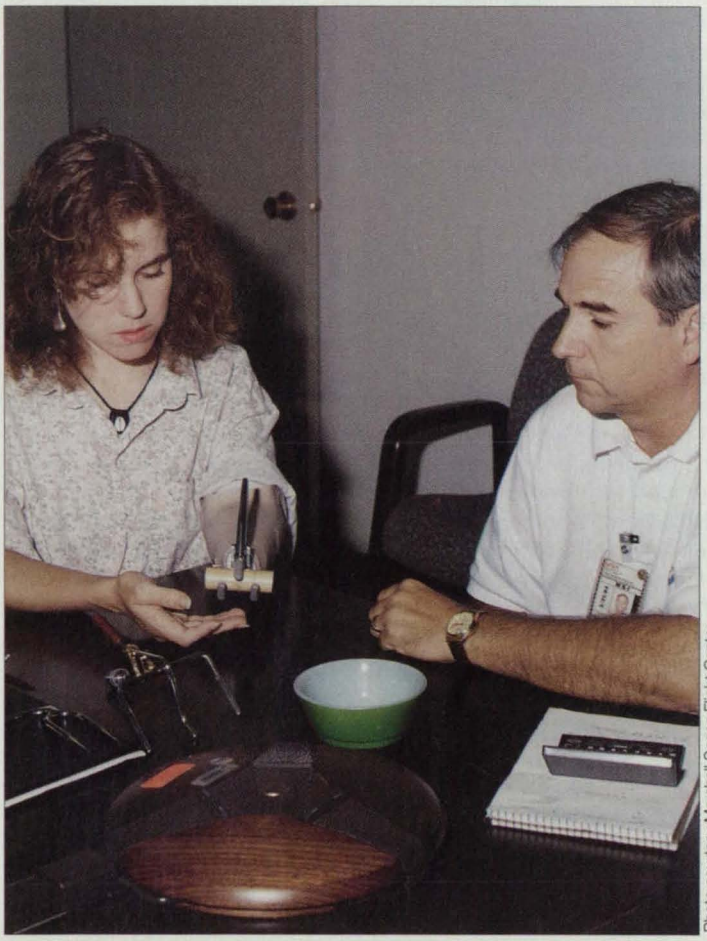

Photo courtesy Marshall Space Flight Center

Sandra Rossi, who lost her lower left arm in a crocodile attack, demonstrates NASA-created prosthetic devices for a variety of activities.

to break free and head for shore, but not before the crocodile had torn off most of Rossi's lower arm.

She was taken to a village clinic, where a doctor amputated what remained of her lower arm, and then flown to a Kenya hospital to recuperate. From there, she phoned her father, George Rossi, to relay news of the incident and inform him that she was coming home. Mr. Rossi turned to *NASA Tech Briefs*, thumbing through his March 1993 issue hoping to see something that might help his daughter. He found a brief describing the Marshall Space Flight Center's work with prosthetic devices for below-the-elbow amputees.

Marshall had started an amputee assistance program in 1988 after Jim Carden, a former Marshall engineer, lost his left hand in a lumber mill accident. Carden found that common prosthetic devices were expensive and limited many of his favorite activities, such as woodworking, fishing, and gardening.

Carden sought help from his friends at NASA and soon a team of engineers set out to develop a general-purpose prosthesis that would permit below-the-elbow amputees to perform a wide range of activities. They created several attachments to help Carden, such as a fishing reel crank, a nail holder, a carving knife, and an attachment for lifting loads of up to 100 lbs.

A Marshall-led biomedical applications team now helps amputees from all over the US by designing custom-made prostheses to aid their daily work and leisure activities. All materials used to fabricate the Marshall arm attachments—mostly stainless aluminum and high-strength aluminum alloys—are scrap or have reached the end of their shelf life, making the cost to amputees minimal.

Following numerous surgeries and months of recovery, Sandra Rossi made her first visit to Marshall in September 1993. She met the members of the biomedical team as well as three other amputees in the program, who shared their experiences and demonstrated their own NASA-created prostheses.

The biomedical team set out to make devices to suit Rossi's specific needs. "They showed me some of the different devices they had, and I told them which ones I thought would be most useful to me," she said. After being fitted with an arm socket by a local prosthetist, Rossi was able to try on an array of custom-made devices such as a grasping clamp, a spatula, a bowl gripper, and a fork attachment.

According to Rossi, the devices help greatly in her daily activities, especially cooking and cleaning. Although the clamp is geared to hold a broom handle, Rossi has found other uses for it. "It's great for peeling carrots. I use it for all kinds of things," she explained.

The quick-release feature of the attachments allows her to switch back and forth between devices—a feature not possible with a conventional hook prosthesis. "I can put it on for half an hour and do something and then take it back off when I'm done," she said.

Rossi is planning a return visit to Marshall to update the biomedical team on her progress and acquire new prosthetic attachments to enhance her leisure activities. "I like photography, so they're trying to make a tripod attachment that I could screw a camera onto," she said, adding that she also would like to try the fishing rod attachment used by Carden. Marshall's amputee assistance program currently is seeking a manufacturer to produce commercial versions of the prostheses.

For more information on the technology described in this article, write in number 761.

Just as an aquarium can offer glimpses into ocean ecology, it can serve as an inspiration and proving ground for future sea-faring technologies.

A pH sensor developed by Ocean Optics Inc., Dunedin, FL, began its journey from fishbowl to ocean in 1986. Mike Morris, one of the company's founders, was working at the Southern Technology Application Center, a NASA-sponsored industry assistance center at the University of South Florida in Tampa.

"As part of my responsibilities, I always read *NASA Tech Briefs* from cover to cover as well as searched past issues for things to meet our clients' needs," Morris said. One day, he came across a brief describing a technique for measuring alcohol vapors, such as those found on a person's breath, that included a means to immobilize color reagents onto a solid substrate. "It gave me an idea of how to immobilize reagents to measure pH in water samples," he recalled. "I developed an immobilized indicator dye—the same one used in swimming pools in drop form—except in this case it was bound to a solid substrate, so it could change color without dissolving away."

In 1988, Morris' new company, pHish Doctor Inc., introduced its first commercial product, a sensor to continuously monitor pH in home aquariums. As pH rises, the ammonia excreted by the fish becomes highly toxic, whereas a drop in pH inhibits the bacteria that normally break down waste products. Either condition can endanger the tank's aquatic community.

The company quickly realized the technology had potential to serve a much broader community. "We wrote an SBIR (Small Business Innovation Research) grant proposal to the Department of Energy to develop a fiber-optic pH sensor for ocean use," said Morris. Oceanic pH levels, which change in response to absorption of CO_2, can serve as an indicator of global warming. Installed on unmanned buoys, the sensors could collect continuous data for long periods.

In 1989, with several partners, Morris formed Ocean Optics to focus on the SBIR proposal. The research team soon discovered that the small spectrometer they needed to precisely measure color shifts in the indicator dye, and thereby make the instrument highly accurate, was not available in existing technology. "So we ended up inventing our own —the world's first miniature spectrometer," said Morris. "It was a real breakthrough, ten times less expensive and a thousand times smaller than anything else on the market."

Photo courtesy Ocean Optics Inc.

A pH sensor based on NASA technology, originally designed for home aquarium use, is finding application in diverse marine environments.

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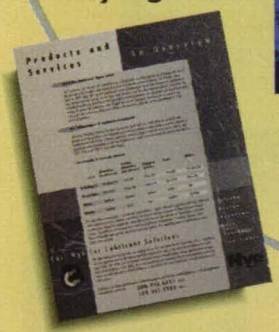

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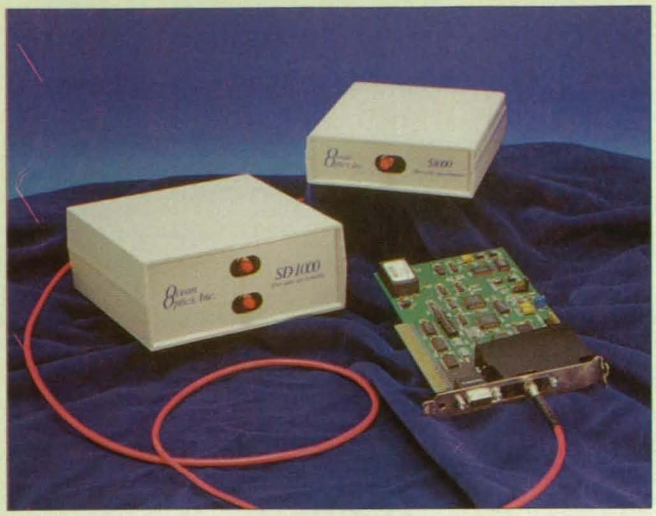


Photo courtesy Ocean Optics Inc.

Ocean Optics' line of miniature spectrometers includes the PC1000, the industry's first PC plug-in model.

The company found that the market for the spectrometer extended well beyond those working with fiber-optic sensors. To date, it has sold approximately 900 units for such diverse uses as ocean-faring submersibles, atmospheric studies, noninvasive detection of skin cancer from reflection spectra, chemical processing, and color quality control in manufacturing. Annual sales of the spectrometers, now available as a PC plug-in card, are expected to reach $3 million in 1994.

Meanwhile, Ocean Optics continues its work on the seawater pH sensor and has developed immobilized dyes to indicate various pH ranges, toxic metals, and redox potential. A sensor currently under development employs both the spectrometer and the dye technology to monitor the pH of well water in a nuclear reactor.

The pH sensor also will serve onboard unmanned underwater vehicles (UUVs) currently under development by the Navy for coastal oceanography. "All of the things that happen in the coastal areas happen on a very short time scale," said Morris. "Say your satellite detects a big plume coming out of the Chesapeake Bay and you want to know what it is. Well, a $100,000-per-day ship may not get there in time or may plow right through it. But you could launch one of these little programmable submarines to race out there and gather data, even in rough weather."

Sensors mounted on the UUVs, and based on the same immobilized dye technology used in pHish Doctor, will help enable quick responses to potentially devastating events such as petroleum spills or algae blooms.

For more information about the technology discussed in this article, write in number 762.

In early 1992, Bob Botos of Loveland, CO faced a life-threatening dilemma. Botos suffered from heavy blockage in his right coronary artery and had endured two heart attacks.

He needed medical treatment to clean out his artery, but was left with no apparent options after his cardiologist had ruled out a coronary bypass and determined that balloon angioplasty—the most popular bypass alternative—would be ineffective against such a thick blockage.

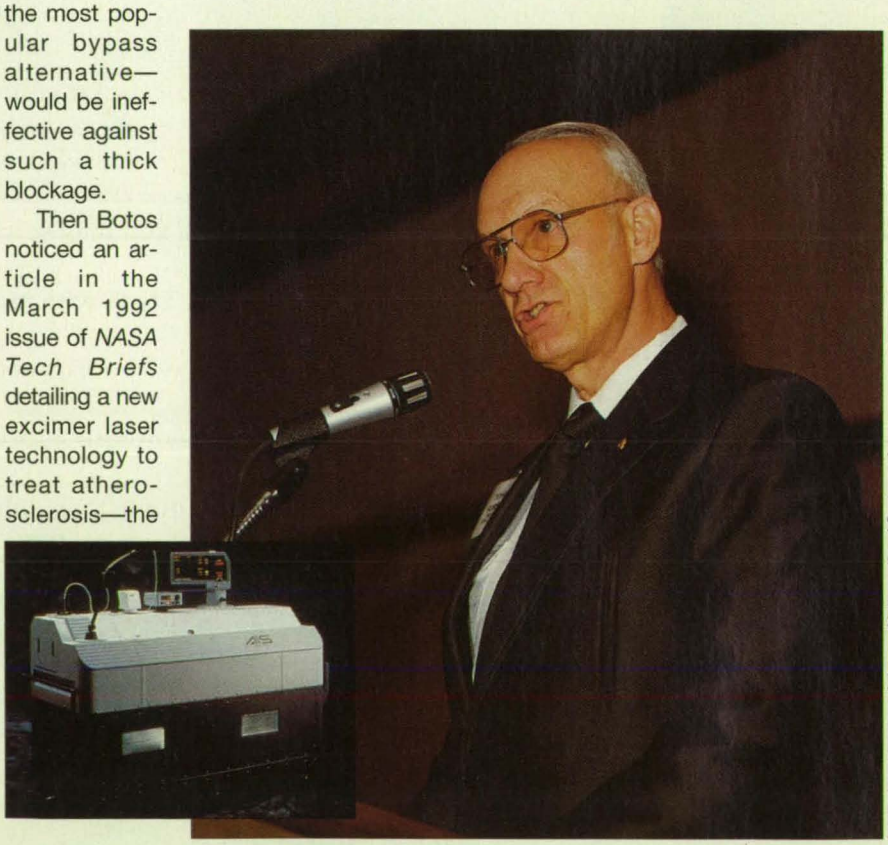
Then Botos noticed an article in the March 1992 issue of *NASA Tech Briefs* detailing a new excimer laser technology to treat atherosclerosis—the buildup of arterial plaque that often causes heart disease. "It was the answer to a prayer," he said.

The article described the Dymer™ 200+ excimer laser system developed by Advanced Interventional Systems (AIS), Irvine, CA. Based on remote sensing and magnetic switching technology developed at NASA's Jet Propulsion Laboratory, the system uses ultraviolet light energy to vaporize fat buildup in coronary arteries without damaging the arterial walls.

Designed to combat extensive lesions of 20 mm or longer, the Dymer 200+ generates a uniform laser beam that pulses at a rate as little as 200 billionths of a second and is navigated with a flexible catheter. The laser operates at 65 °C, a temperature safe for human tissue.

After reading the article, Botos immediately called AIS and learned that a Dymer 200+ unit would be installed at St. Anthony's Central Hospital in Denver that summer. Botos then phoned a Denver cardiologist and arranged the surgery for himself, becoming the seventh patient to undergo laser angioplasty at St. Anthony's on June 3, 1992.

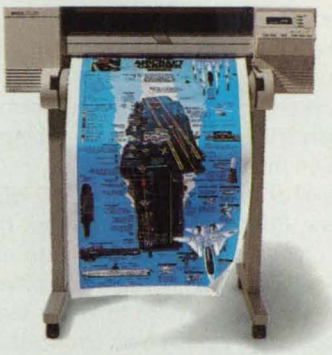
During the surgery, the doctor discovered that Botos had six to eight



Inset photo courtesy Advanced Interventional Systems, Inc.

Bob Botos tells an audience at the Technology 2002 Conference how an innovative medical technology he discovered in* NASA Tech Briefs *changed his life. Botos underwent laser angioplasty using the Dymer™ 200+ (inset) created by Advanced Interventional Systems Inc., which recently merged with The Spectranetics Corp., Colorado Springs, CO.

The Unplodder.



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centimeters of arterial plaque buildup, which the laser angioplasty completely dissipated. With balloon angioplasty, plaque is compressed against artery walls and patients must routinely have the procedure redone to open arteries that have clogged again. After completing a short cardiac rehabilitation program, the only medical attention that Botos has needed is a routine annual checkup.

"I felt a change almost overnight," Botos stated. "I didn't get short of breath, and had much more endurance for all types of physical activity."

Botos, a Hewlett-Packard program manager who resides two miles from his office, is now able to walk to work as well as engage in bicycling and aerobics. "Thanks to the article in *NASA Tech Briefs*," he said, "I am living a fuller, more productive, and much more pleasant life."

For more information on the technology described in this article, write in number 763.

Stevie Roper, who suffers from a rare skin disorder, lives a more active live with the use of a NASA-derived cool suit.

Sarah Ann Moody never intended to start a foundation. She only wanted to help her nine-year-old nephew Stevie lead a normal life. But as soon as word got out about how a NASA-derived cool suit had brought relief to Stevie, victim of a rare skin disease called hypohydrotic ectodermal dysplasia (HED), Moody's phone began ringing off the hook.

Like all of the nation's 400-1000 HED sufferers, Stevie was born without the sweat glands needed to eliminate excess body heat. As a result, any physical exertion or exposure to warm temperatures could induce heat stroke. During a 1976 visit with his aunt, Stevie became overheated in a non-air conditioned car and had to be doused with cold water from a nearby lawn hose.

The close call prompted Moody to seek help from NASA's Langley Research Center. Langley's Technology Utilization Office put Moody in touch with Life Support Systems Inc. (LSSI), Mountain View, CA, a manufacturer of personal cooling gear based on technology developed for the Apollo astronauts. With the help of local Po Folks restaurants, Moody raised enough money to purchase a custom cool suit for Stevie.

A scaled-down model of the LSSI cool suits typically worn by military pilots, industrial firefighters, and race car drivers, Stevie's suit consists of a helmet liner and vest that fit comfortably beneath his clothes. An antifreeze solution cooled by a portable, battery-powered refrigeration unit is pumped through tubes to the garments, which are made of Flexitherm™, a temperature-sensitive fabric. The system can eliminate 40-60 percent of the boy's stored body heat while lowering his heart rate by 50-80 beats per minute.

"The suit turned his life completely around," said Moody. "And I began to get calls from people who had children with similar problems." A documentary film of Stevie's story was shown on approximately 800 TV stations worldwide, alerting people as for away as India, New Zealand, Kuwait, and Argentina. In 1987, with the continued support of Po Folks Restaurant Corporation, Moody established the HED Foundation to help purchase cool suits for the children on her swelling list of applicants.

When an article on Stevie was published in *NASA Tech Briefs* in 1988, "we started to get even more calls," reported Moody, who appeared on Good Morning America in the same year and in a *Spinoff 1989* article. "We had not just the childrens' parents calling, but doctors and scientists who, as the result of reading *NASA Tech Briefs* or *Spinoff*, wanted to know the ins and outs of how the suit worked and whether it would benefit a certain child. It led from HED to treatment of all sorts of conditions—lamellar ichthyosis, cerebral palsy, spina bifida, quadriplegia, chromosome syndromes, and severe burns."

To date, the foundation has placed more than 200 suits with children worldwide. "For most of the children, the cooling gives them a quality of life they didn't have," said Moody. "Before, they were confined to air-conditioned homes, cars, malls ... no picnics, no amusement parks. And when you confine the child, the whole family is confined."

Elected in 1993 to the Space Technology Hall of Fame, the cool suit continues to prompt new medical applications. It has been found to offer symptomatic relief to people suffering from multiple sclerosis (MS), a chronic, progressively disabling disease of the central nervous system afflicting approximately 300,000 people in the US. Wearing the suit can alleviate such MS symptoms as fatigue, loss of balance, slurred speech, impaired vision, and loss of coordination. It also can enhance endurance during exercise and physi-

NASA recently signed an agreement with the Multiple Sclerosis Association of America (MSAA) to further investigate how NASA technology can aid MS patients. At the signing ceremony, held at the National Rehabilitation Hospital (NRH) in Washington, DC, the Technology Utilization Foundation (TUF) donated $10,000 to place cool suits in the homes of MS patients. (Back—L to R) Daniel Goldin, NASA Administrator; Edward Eckenhoff, NRH President; Dr. Richard Materson, NRH Vice President; Bill Schnirring, TUF President; (Front—L to R) John Hodson, MSAA President; Madlyn Rhue, actress and MS patient.

cal therapy.

The Multiple Sclerosis Association of America, like Moody's HED Foundation, is developing programs to get the cool suits to patients who need them.

For more information on the technology described in this article, write in number 764.

LaCrosse, Wisconsin is home to Norplex Oak Inc., one of the leading manufacturers of laminates for printed circuit boards. A laminate is comprised of sheets of prepreg placed between copper foil. Prepreg is created by impregnating a continuous glass cloth, or web, with epoxy resin and partially curing it by applying heat.

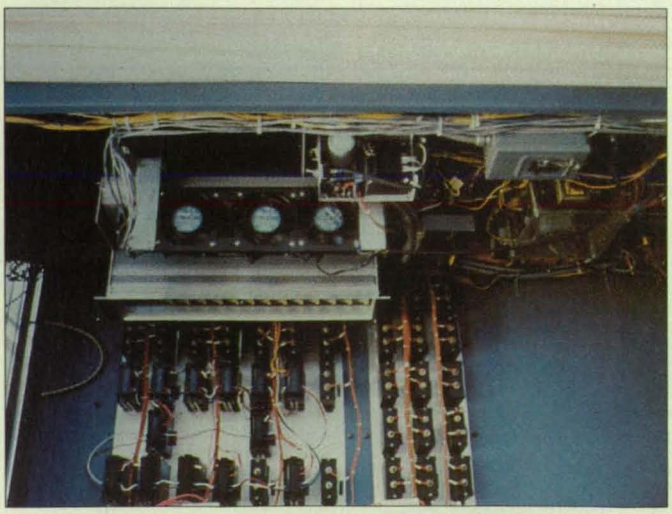
To lower the cost of producing prepreg and to reduce emissions, Norplex Oak decided to switch to infrared treating towers for curing instead of using hot air systems. This required developing infrared treaters and designing a tower with optimal heat transfer characteristics for prepreg. For help, the company turned to NASA.

Bruce Kline, a Norplex Oak engineer, read in *NASA Tech Briefs* about a technique developed at Jet Propulsion Laboratory for processing data captured by an infrared radiometer and converting it into a map of thermal irradiance over a large area. This technique was a product of JPL's work on mathematical simulation of solar and planetary infrared heat loads on spacecraft. Kline obtained a Technical Support Package and compared NASA's research results with his own.

"We found that their work was nearly identical to ours and validated our findings," said Kline. The NASA data not only confirmed the company's computer model prediction of the heat flux pattern, but also enabled it to enhance consistency of the curing process by modifying its infrared treaters. Further, it provided a theoretical basis for development of optimal heater placements, allowing the treater tower to produce an even infrared heat transfer to the web.

Several of the new infrared treaters are used now in production, successfully operating at higher speeds with improved product consistency.

For more information about the technology described in this article, write in number 765.



Norplex Oak used data processing technology developed by NASA for simulation of infrared heat loads on spacecraft to more efficiently produce prepreg for printed circuit boards.

In 1990, the Dubuque, Iowa Utility Department installed a new computer system for the process control of water treatment. Almost immediately after the system became operational, they ran into a major problem—the system began to experience "common brownout grounding problems." Signal losses were occurring because the analog inputs into the computer were not compatible or significantly out of tolerance with the way the system was grounded, which made the inputs vulnerable to interference from machinery and storms.

"There was only enough voltage for us to put burnout chips on the analog signals," reported Bob Ervolino, an electronics technician with the Utility Department's Water Division. "We were ordering these quite often, at 25 dollars per chip."

Ervolino's group traced the problem to a deficiency of signal isolators on the analog input cards. Most of the trouble originated in the main plant pump room; the pumps have thermocouples mounted on the bearings and their signals are not isolated from the computer inputs.

They first looked at off-the-shelf commercial items, which were quite expensive at the time, priced in the range of $250 per point. "We had 50 to 75 different analog points that were affected," he recalled. Budget constraints dictated that the solution be more cost-effective.

One day, while reading *NASA Tech Briefs*, Ervolino found the answer. An article from the Ames Research Center described "Output Isolation and Pro-

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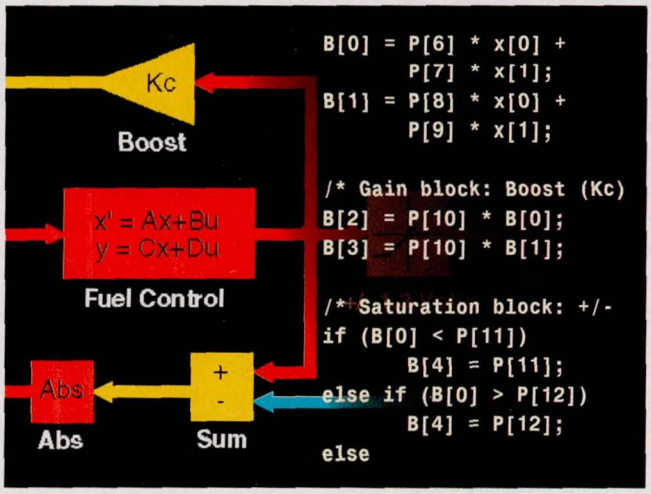

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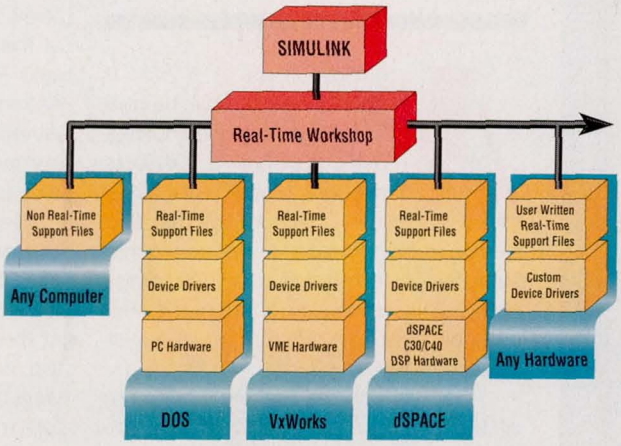

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For More Information Write In No. 514

Low-cost signal isolators described in* NASA Tech Briefs *were applied by the Utility Department of Dubuque, Iowa to solve a computing problem.

tection Circuits" as a solution to a problem similar to the Water Division's. "The [tech brief] gave us a background in the device; how to use it and how to implement the circuits ourselves," he said. Ervolino obtained a Technical Support Package and contacted the vendor supplying the circuit described in the report, Analog Devices of Norwood, MA.

"They had two different devices that would work well for our applications. We ended up purchasing one of each—and found the right one for our use. We built most of our equipment on site and everything worked great.

"We saved the Water Division more than 50 percent of the cost of a commercial solution to the problem," he added, "and were equipped to make the repairs in-house if problems ever arose again."

For more information about the technology described in this article, write in number 766.

A simple idea in a *NASA Tech Briefs* article helped the American Red Cross (ARC) solve a serious security problem. In 1990, the ARC facility in Redford, MI installed a large Vulcan Freezer to house plasma samples for a retrovirus epidemiology study. This repository contained in excess of a million plasma samples—all irreplaceable.

After working the technical bugs out of the box and getting it to operate within the desired temperature range, ARC personnel found they had another, larger problem: Individuals in the building were tampering with the liquid line control valves that operated the main and backup systems supplying the refrigerant to cool the unit. If they didn't act quickly, the samples could be lost.

"We had to figure out a way to prevent someone from turning off the valves," explained Thomas Wrona, an ARC representative. "This had to be done so that either you would need a key to close them or it would be so difficult to do by hand that it would require a tool. I realized we'd have to engineer a system that could lock these valves on and, at the same time, allow them to be shut off in case of an emergency."

Wrona, a long-time *NASA Tech Briefs* subscriber, found an article in the magazine illustrating a way to use steel banding to strap on pallets while securing valves either in one position or another. Using common hand tools and some excess banding he obtained from the facility's loading dock, Wrona devised—in a few hours—a system similar to that outlined in the brief.

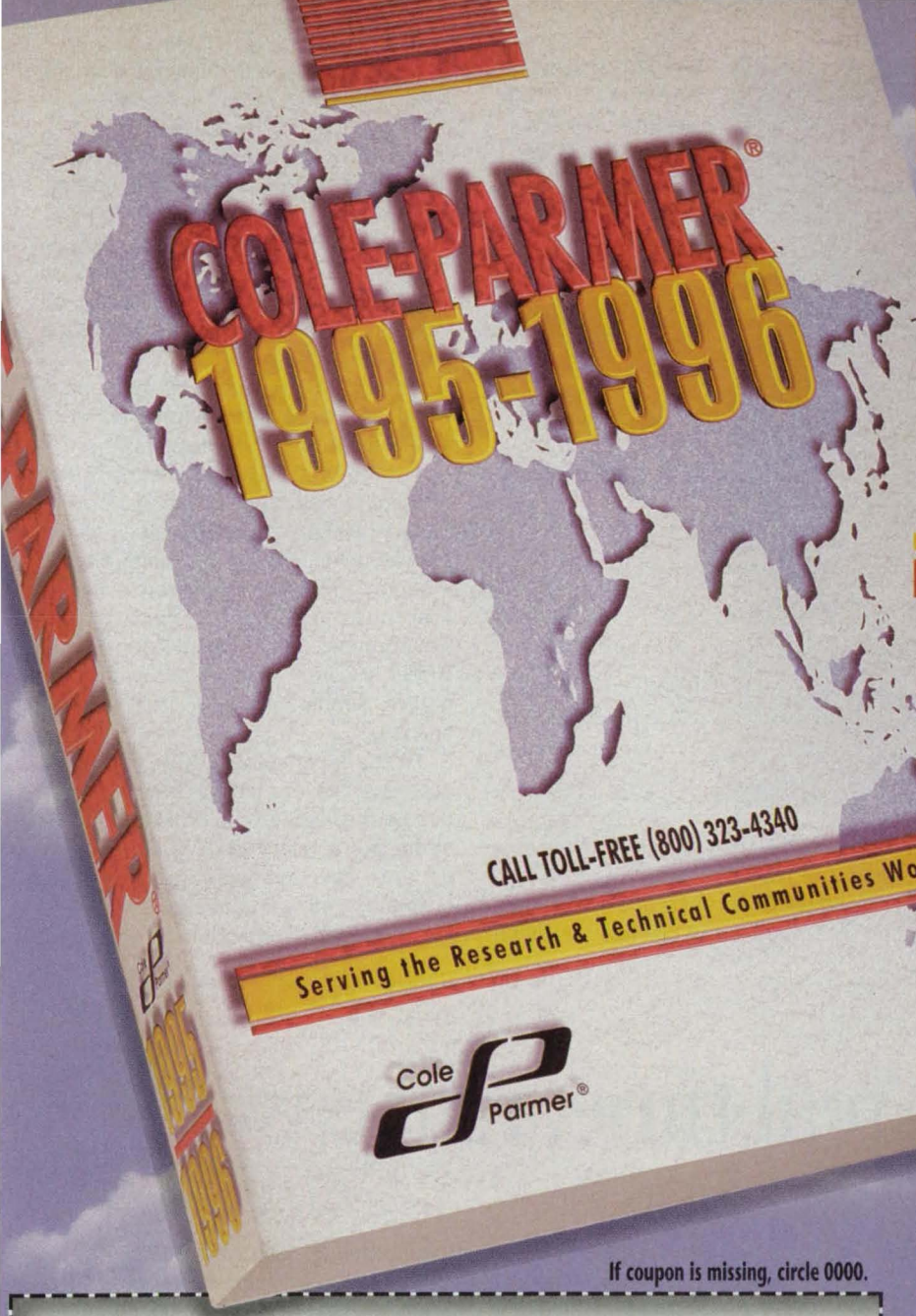
"I was able to prevent the valves from being moved," said Wrona, "and it cost us next to nothing. Since then, we've never had any problem with anyone turning the valves."

For more information about the technology described in this article, write in number 767.

You may remember seeing the Flogiston Chair suspended from the ceiling of the doctor's basement in the movie "The Lawnmower Man." Brian Park—engineer and principal of the Flogiston Corporation, Austin, TX—designed the chair in the 1980s with help from NASA.

"I was browsing through *NASA Tech Briefs* looking for information about some of the publications that NASA offered," said Park. "I ran across a book called *Anthropomorphic For Engineers* that contained three volumes of data about the human body size, shape, and motion characteristics. I wrote away for a copy."

He used the data over the next year in creating the first chair to assist with mind/body relaxation. NASA put him in touch with John Jackson, a researcher at the Johnson Space Center in Houston, who invited him to the center to review biographs about neutral body posture that were drawn from a video taken



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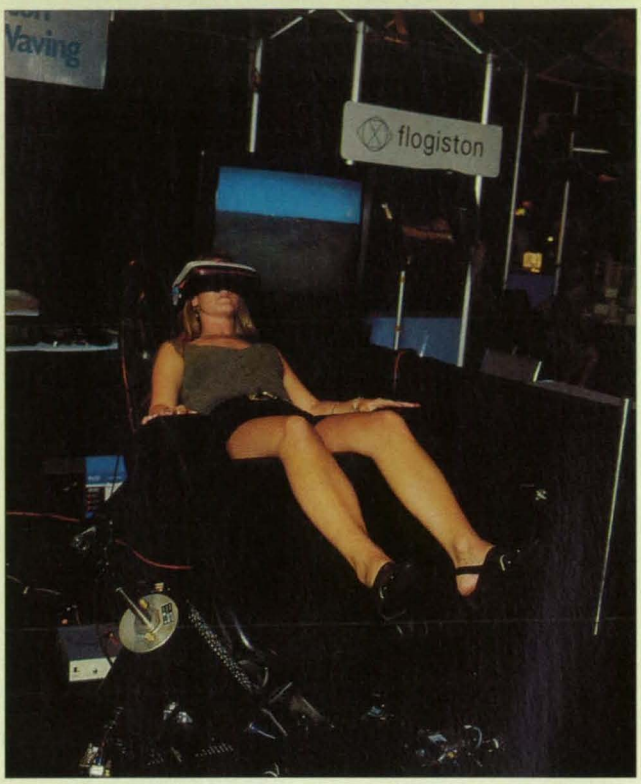


Photo courtesy Flogiston Corp.

The NASA-inspired Flogiston Chair—which mimics the natural position a body assumes in weightless space—is used for relaxation, microgravity training, and virtual reality applications.

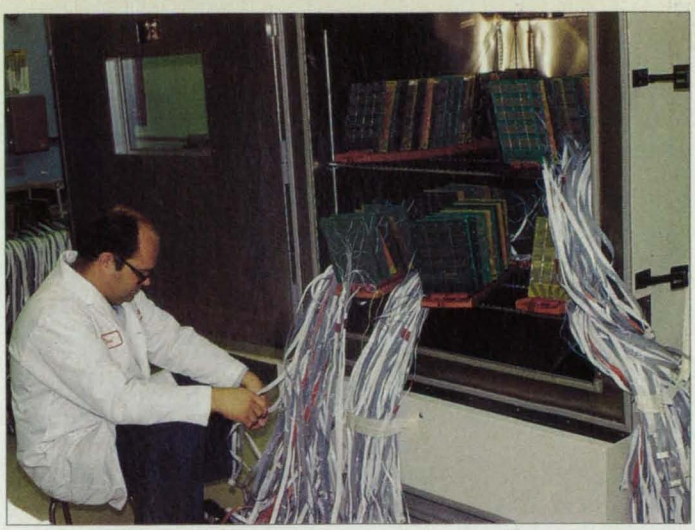
aboard Skylab. "When I looked at the neutral posture, I realized immediately that that was the posture of the chair I was trying to design," he said. "I built a wooden prototype, then sat on it for several years trying to figure out what it was for."

Eventually he realized that the posture was suitable not just for meditation and relaxation, but for what he calls "real space" or—more important—as an interface with cyberspace. "Basically, this is the optimum posture of relaxation the body wants to have if you remove all external forces," explained Park.

In 1989, Park bought a company in Austin and began to build the chairs en masse. "I was ahead of my time," he said, "so I had to wait for the rest of the planet to catch up with me."

Then, last year, he was awarded a Small Business Innovation Research (SBIR) grant to further develop his novel chair. The work involved mounting the Flogiston Chair on a motion platform to be used for training astronauts in virtual environments. Park's "Personal Motion Platform (PMP)" was delivered in July to the Johnson Space Center's Virtual Environment Technology Laboratory, where it will be used in extravehicular activity simulations and other training scenarios.

At the recent SIGGRAPH computer graphics conference in Orlando, Park used a duplicate of the PMP to demonstrate the concept of "Waving," which he described as "letting go of your awareness of real space and connecting your mind directly with cyberspace."



Trace Laboratories helps companies switch to environmentally friendly solvents by testing their effectiveness in electronics parts processing.

Attendees were immersed in an environment combining computer graphics, vision, sound, music, motion, and subsonic vibration.

"This system is our first attempt to fully immerse the sensorium in cyberspace," explained Park. "I think it's how we'll live in cyberspace for years to come—we will have rooms where people go flying together."

For more information about the technology described in this article, write in number 768.

Trace Laboratories of Chicago, IL, provides testing services to the electronics industry. Recently, there was a major push within the industry to rid itself of ozone-depleting chemicals (ODCs) such as freon and similar types of solvents used to remove flux residue from electronic parts after they are processed.

Environmental concerns spurred the industry to develop substitute cleaners, substitute fluxes—all sorts of substitutes—none of which had been tested.

"Electronics manufacturers who use us as a test lab were asking, 'We just changed our process—we no longer use ODCs—what kind of test can you run to verify that our new process is going to be sound and reliable?'" recalled Jeffry Schutt, general manager for Trace Laboratories. While reading *NASA Tech Briefs*, Schutt came across two articles discussing surface installation resistance, a technique that can be used to measure the degree of contamination on a surface. "That's exactly what we offered our customers who were seeking to change their processes," he said. "We were able to improve our testing techniques and provide a better service to our customers—so that they could then make an informed decision about the new processes with which they were experimenting."

"*NASA Tech Briefs* showed how it was being done at the component level on dyes," said Schutt. "We just extrapolated that concept to do it at the board level on surfaces such as laminates and conformal coatings, and solder massing."

Today, the laboratory still performs surface installation resistance testing when a manufacturer switches to a new type of flux. "We'll let the manufacturer know that there appears to be no long-term deleterious effects," explained Schutt. "Or we may advise them that we ran the test for one day—the parts failed—and they should reconsider the change."

For more information about the technology described in this article, write in number 769.

We'd like to hear *your* story:

If you have successfully applied technology described in *NASA Tech Briefs*, please use the Reader Feedback Card (page 134) to tell us how.

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 20). NASA's patent-licensing program to encourage commercial development is described on page 20.

Flexible Wedge Seal for Ball Valve

The wedge would flex around the ball at the locus of contact, thereby creating an effective seal with less force on the ball than if a hard valve seat were used. Less torque would be needed to close the valve, and a small actuator could be used.
(See page 115.)

Dashpot Damps Oscillations in Check Valve

A dashpot and a dashpot ring eliminate the self-sustaining oscillations that cause premature wear and jamming of the poppet mechanism.
(See page 113.)

Thermotile Refrigerators

A proposed modular cooling device would include thermally conductive heat-transfer surfaces, a thermoelectric cooling device, a temperature sensor, and logic and control circuits. Thermotiles would eliminate conventional mechanical refrigeration machinery and its associated lubricants and chlorofluorocarbons.
(See page 82.)

Bioconvective Patterns Indicate Concentrations of Cadmium

This sensitive method can be used to detect aqueous cadmium and other heavy-metal pollutants in water.
(See page 128.)

All-Metal Tires

Originally conceived for use on a rover vehicle on Mars, these tires can be used on vehicles and robots that fight fires or clean up dangerous chemicals on Earth.
(See page 116.)

Simplified Digital Subband Coders and Decoders

In comparison with earlier units, these coders and decoders offer the advantage of simplicity and speed.
(See page 76.)

Hand-Controlled Brazing-Paste Dispenser

A switch added to a hand-held brazing-alloy-paste dispenser yields improved, more consistent brazing-alloy beads. The dispenser has been used to apply the paste between adjacent tubes in a heat exchanger.
(See page 124.)

Programmable Switch Solutions.

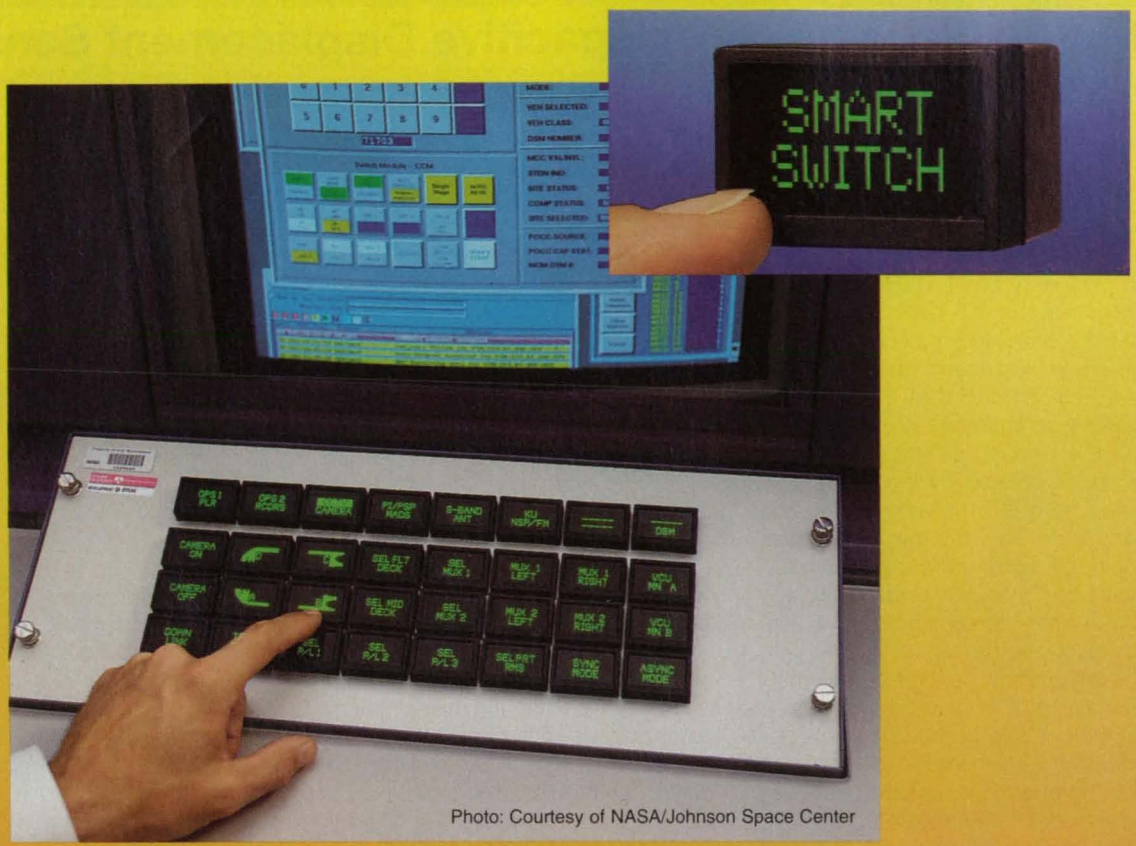


Photo: Courtesy of NASA/Johnson Space Center

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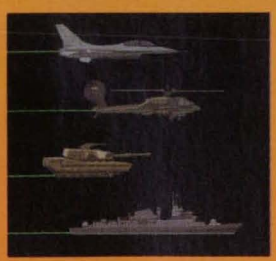

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Special Focus: Sensors

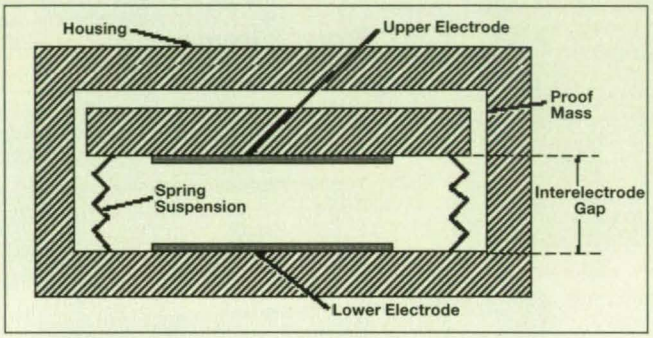
Ultra-High-Frequency Capacitive Displacement Sensor

Resolution is finer than 10^{-14} m/Hz$^{1/2}$, and frequency response is flat up to 20 MHz.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype of an improved class of compact, high-resolution capacitive displacement sensors operates at an excitation frequency of 915 MHz and measures only about 7.5 by 4 by 2 cm. A capacitive displacement sensor typically includes two closely and variably spaced metallic electrodes that constitute a capacitor (see figure), plus an electronic circuit that measures the variation in capacitance caused by the variation in distance between the electrodes. The capacitance can be measured, for example, by exciting the capacitor with an alternating voltage and measuring the displacement current flowing in the capacitor. (Note that as used here, "displacement current" denotes the alternating current that is proportional to the capacitance, and should not be confused with "displacement," which here means the change in distance between the electrodes.) Heretofore, capacitive displacement sensors have operated at excitation frequencies of 5 MHz and less, with concomitant limitations on the frequencies of measurable displacements.

In the case of a capacitive position sensor based on a simple displacement-current measurement, an increase in the excitation frequency offers the advantage of increased bandwidth (that is, increased frequency range of measurable displacements) because the bandwidth is typically some significant fraction of the excitation frequency. Another advantage is related to the fact that increasing the excitation frequency increases the displacement current in the capacitor at a given excitation voltage: the shot-noise-limited signal-to-noise ratio associated with the measurement of the displacement current is proportional to the square root of the excitation frequency, so that increasing the excitation frequency also increases the resolution of the capacitance measurement.



A Capacitive Displacement Sensor can be an integral part of a small accelerometer or seismometer, wherein it is used to measure the displacement of a proof mass.

The prototype sensor contains a commercially available 915-MHz oscillator and a transmission-line resonator. The resonator, in turn, contains a stripline inductor in addition to a variable capacitor. Although the principle of operation and the signal-to-noise ratio of this sensor are somewhat different from those of a sensor based on a simple displacement-current measurement, the ultrahigh excitation frequency still offers the advantages of resolution and frequency response better than those of older sensors. The prototype sensor exhibits a resolution finer than 10^{-14} m/Hz$^{1/2}$, a flat frequency response for interelectrode-gap-variation frequencies from dc to 20 MHz, and a dynamic range of 10^9. It is also not deleteriously affected by mechanical overdriving, not even by contact between the electrodes.

This work was done by Thomas R. VanZandt, Thomas W. Kenny, and William J. Kaiser of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 27*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: William T. Callaghan, Manager; Technology Commercialization; JPL-301-350; 4800 Oak Grove Drive; Pasadena, CA 91109.

Refer to NPO-18675, volume and number of this NASA Tech Briefs *issue, and the page number.*

Active Targets for Capacitive Proximity Sensors

Signals from the targets can be used for alignment.

Goddard Space Flight Center, Greenbelt, Maryland

Lightweight, low-power active targets have been devised for use with the improved capacitive proximity sensors described in "Capacitive Proximity Sensor Has Longer Range" (GSC-13377), *NASA Tech Briefs*, Vol. 16, No. 8 (September 1992), page 22, and "Capacitive Proximity Sensors With Additional Driven Shields" (GSC-13475), *NASA Tech Briefs*, Vol. 17, No. 11 (November 1993), page 40. The active targets are short-distance electrostatic beacons; they generate known alternating electrostatic fields that can be used for alignment and/or to measure distances.

The improved capacitive sensors — called "capaciflector" sensors — include sensing electrodes and driven shields. The frequency of an oscillator in a capaciflector varies with the capacitive coupling between the sensing electrode and an external object; the frequency thus serves as a coarse indication of the distance to the object. The driven shield(s)

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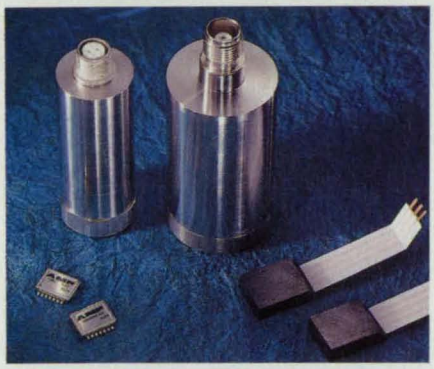

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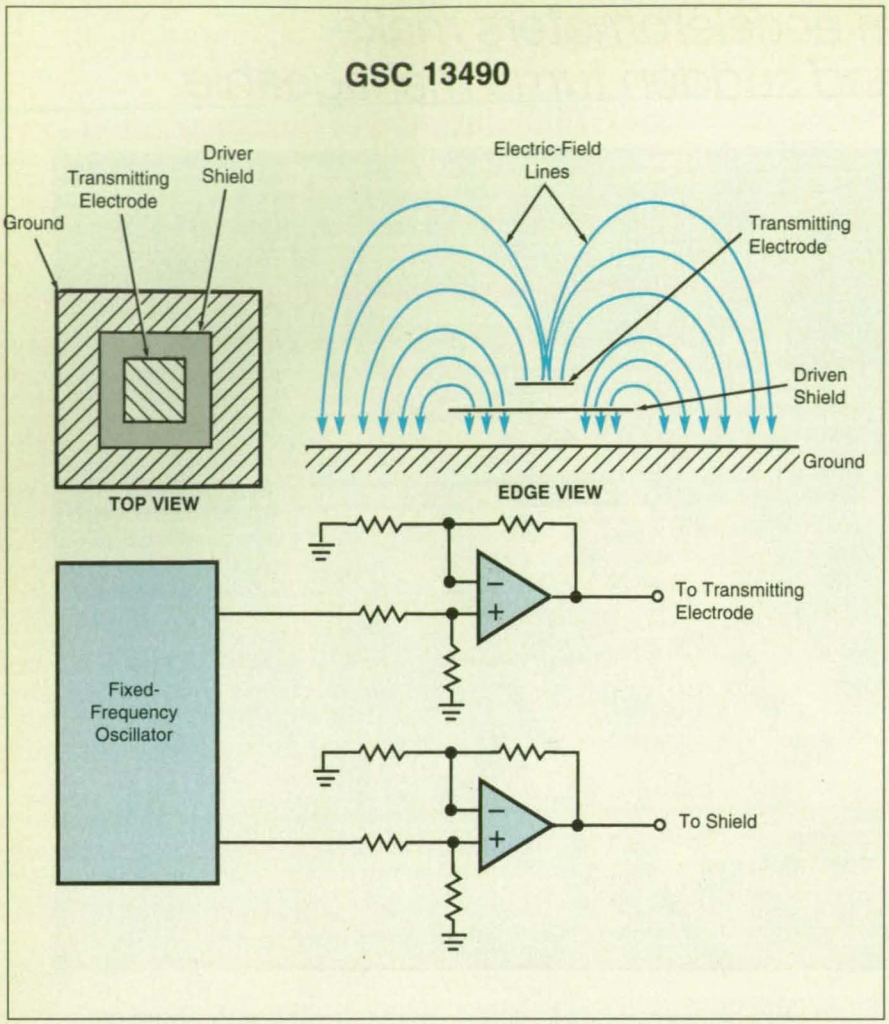


The **Active Target** generates an electrostatic field that alternates at a fixed frequency.

(which are driven at the same frequency and in phase) concentrate(s) the electrostatic field from the sensing electrode into the exterior space, thereby extending the sensing range.

An active target is similar to a capaciflector sensor in some respects. It includes an optional driven shield and a transmitting electrode, both driven in phase at the same frequency (see figure). The driven shield increases the range in the same manner as that of the capaciflector sensor. However, unlike in the capaciflector sensor, the oscillator operates at a fixed frequency.

When a capaciflector sensor encounters the electrostatic field generated by an active target, this field superimposes a signal at the target frequency upon the variable-frequency oscillator signal in the sensing electrode. The strength of the target-frequency signal is a measure of the distance between the sensor and the active target. Thus, the sensed target-frequency signal can be separated by a filter and processed separately into an indication of the distance. Signals from multiple targets detected by multiple sensors can be processed simultaneously to determine orientation as well as distance, as explained in more detail in the following article.

This work was done by Del T. Jenstrom and Robert L. McConnell of **Goddard Space Flight Center**. *For further information,* ***write in 63*** *on the TSP Request Card. GSC-13490.*

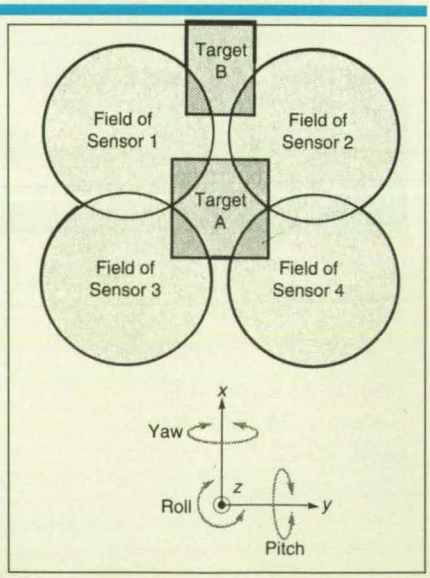
Capacitive Sensors and Targets Would Measure Alignments

Layouts of targets and sensors would enable interpretation of signals in terms of distances and angles.

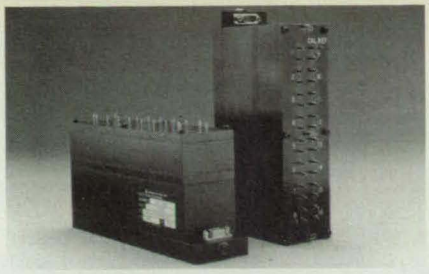
Goddard Space Flight Center, Greenbelt, Maryland

Multiple capacitive sensors and active targets, like those described in the preceding article, would be used to measure the distance between, and the relative orientation of, two objects, according to a proposal. In a typical application, one of the objects would be a robot, and the other would be a workpiece that the robot must grasp or attach to another workpiece. In another typical application, the two objects might be docking assemblies on two vehicles that are to be joined. In these and other applications, the sensed target signals would be processed and used by control systems to align the objects to be joined.

The shapes, sizes, and layouts of sensors and targets can be optimized for a specific application. The figure shows an example of two active targets on a flat surface of one object and four sensors on the facing flat surface of another object. The two active targets would operate at different fixed frequencies so that the signal from each target received by each sensor could be extracted and processed independently. The particular layout of targets and sensors would enable the determination of the relative position and orientation of the two objects in all six degrees of freedom. This layout is optimized for a desired alignment in which (a) target A is centered in



Capacitive Sensors arranged in a square on the x–y plane of one object would detect the relative position and orientation of a plane containing targets A and B on another object. The objective is to align the two objects so as to make the target and sensor planes parallel and to center the targets as shown.



ELECTRONIC PRESSURE SCANNERS

The ESP-16BP scanners consist of 8 or 16 silicon piezoresistive pressure sensors, one for each port. Sensor outputs are internally multiplexed at 20,000 Hz through an on-board instrumentation amplifier. An integral manifold enables on-line calibration of the sensors to characterize them at the condition in which they are being used. On-line calibration provides static errors of less than ±0.05% FS. ESP-16BP scanners are ideal for transient pressures and form the basic element for PSI's S1600HD rackmount scanners for steady state pressures. Both scanners can be integrated with PSI's System 8400 to provide a complete high-performance pressure acquisition system for gas turbine research. PSI, 1-800-687-SCAN. Circle #636

INTELLIGENT PRESSURE SCANNERS

The 9010 and 9015 scanners are compact, low-cost pressure acquisition modules that integrate 8 or 16 silicon piezoresistive pressure sensors with a 32 bit microprocessor. The on-board microprocessor performs digital temperature compensation and linearization of the sensors to output data via RS-422/RS-485 using industry standard protocols. An integral manifold enables on-line rezero of the sensors on demand. Static system accuracy is ±0.08% FS with total temperature errors of less than ±0.001% FS/°C. Intelligent Pressure Scanners are components of a networked data acquisition concept called System 9000. PSI, 1-800-678-SCAN. Circle #637

FLIGHT PRESSURE SYSTEM

The S8256 Flight Pressure Measurement System is designed for airborne applications requiring up to 512 pressures to be measured at rates of 10,000 channels per second. A 32 bit microprocessor provides digital thermal compensation and linearization of PSI's pressure scanners to provide ±0.25% FS accuracy over a wide temperature range. Engineering unit data is output via a PCM-compatible 16 bit digital interface. The small size (3.3" x 4.9" x 12.1") and the rugged packaging of the S8256 make it suitable for all types of aircraft. PSI, 1-800-678-SCAN. Circle #638

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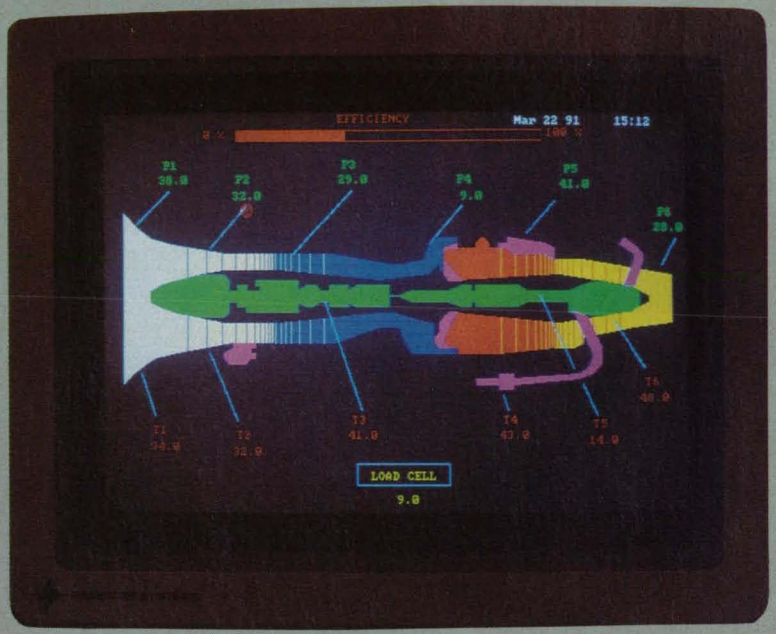

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an x–y plane between all four sensors, (b) target B is equidistant from sensors 1 and 2 and on the $+x$ side, (c) the x–y plane that contains the sensors is parallel to the plane that contains the targets, and (d) the distance between the two planes (along the z axis) has a specified value.

Information on the relative position and orientation of the two objects could be determined as follows:

- The distance(s) along the z axis could be extracted from those components of the outputs of the sensors that pertain to the proximity of the sensed surface regarded as a passive target.
- Displacement(s) along the y axis could be determined by comparison of the target A responses of sensors 1 and 3 with the target A responses of sensors 2 and 4.
- Displacement(s) along the x axis could be determined by comparison of the target A responses of sensors 1 and 2 with those of sensors 3 and 4.
- Pitch about the y axis could be determined by comparison of the passive-target outputs of sensors 1 and 2 with those of sensors 3 and 4.
- Yaw about the x axis could be determined by comparison of the passive-target outputs of sensors 1 and 3 with those of sensors 2 and 4.
- Roll about the z axis could be determined by comparison of the target B response of sensor 1 with that of sensor 2.

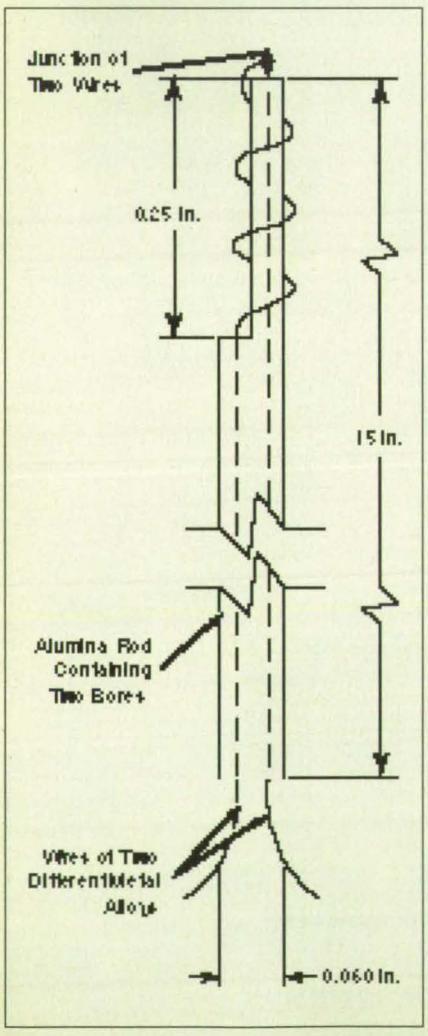
This work was done by Del T. Jenstrom of **Goddard Space Flight Center**. *For further information,* ***write in 62*** *on the TSP Request Card. GSC-13491.*

Sensor Detects Semiconductor Escaping From Ampoule

Electrical resistance and temperature change upon exposure to semiconductors.

Marshall Space Flight Center, Alabama

Figure 1 illustrates an electrochemical sensor that detects semiconductor materials escaping from a broken fused-silica ampoule. The ampoule contains such materials in a crystal-growth furnace. The sensor is small enough to be placed inside a metal cartridge that surrounds the ampoule in the furnace. Typically, the ampoule is charged with toxic semiconductor materials like PbSnTe, HgZnTe, and GaAs. This sensor can be used to shut down the furnace automatically if the ampoule breaks and thereby prevent the further release of molten semiconductor, which could quickly breach the surrounding thin wall [0.010 to 0.020 in. (0.25 to 0.50 mm) thick] of the cartridge, damage the furnace, and/or release toxic vapors into the surrounding area.



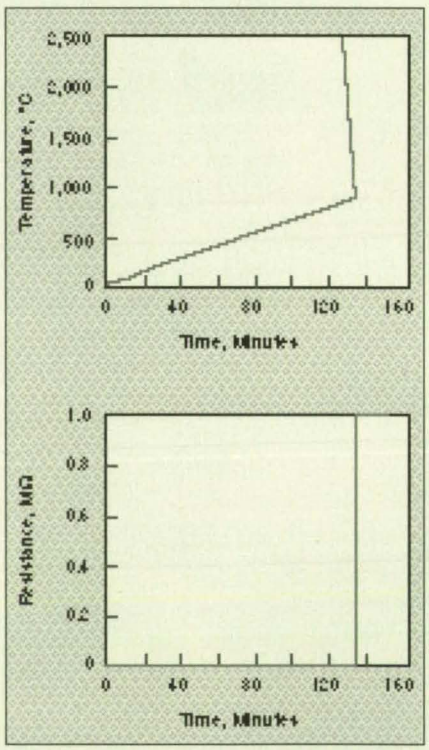


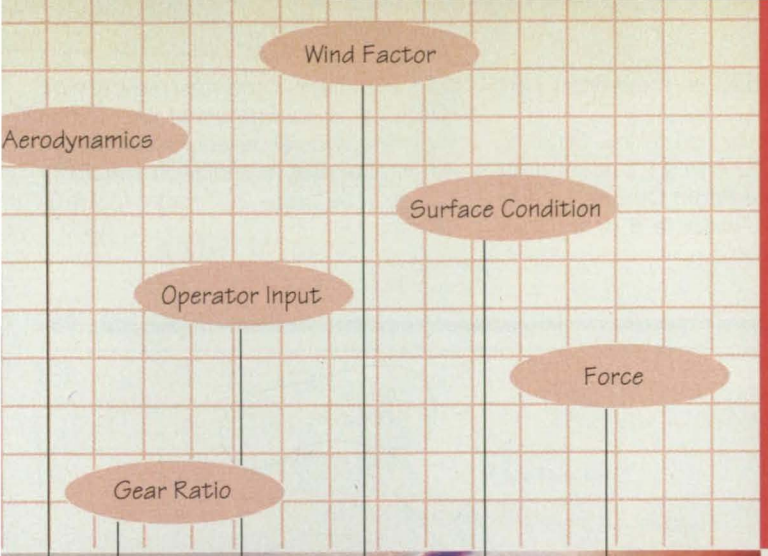
Figure 1 (left). **This Sensor Detects the Breakage** of an ampoule that contains molten semiconductor. The chemical reaction between the hot semiconductor material and the wire causes a step increase in the electrical resistance and temperature of the wire.

Figure 2 (above). **This Step Increase in Temperature and Resistance** of a prototype sensor indicates the presence of hot GaAs.

The sensor capitalizes on the chemical reactions that occur between semiconductors and metals at the melting temperatures of the semiconductors. The sensor contains two wires made of dissimilar metals with a junction between them to form a closed electrical circuit. The chemical reactions between the two dissimilar metals and the semiconductor materials increase the electrical resistance of the sensor in a step of the order of megohms. The use of two dissimilar metals in the sensor also enables it to measure temperature via the voltage produced by the Seebeck effect. Therefore, resistance and voltage measurements can be taken alternately at a frequency of approximately 1 Hz.

The sensor was tested with HgCdTe and GaAs semiconductor materials. In each case, the material was placed in a boron nitride crucible, which was placed inside a quartz liner in a crystal-growth furnace. The sensor was placed through a groove in the crucible into the volume containing the semiconductor material. (This setup simulated the case in which the ampoule was already ruptured before processing.) The temperature was increased, and the resistance and temperature of the sensor were recorded until step increases of resistance (see Figure 2) indicated that the sensor was exposed to the vaporous or molten semiconductor material.

Because of the step increase in resistance, the sensor can be regarded as operating in a simple on/off mode that



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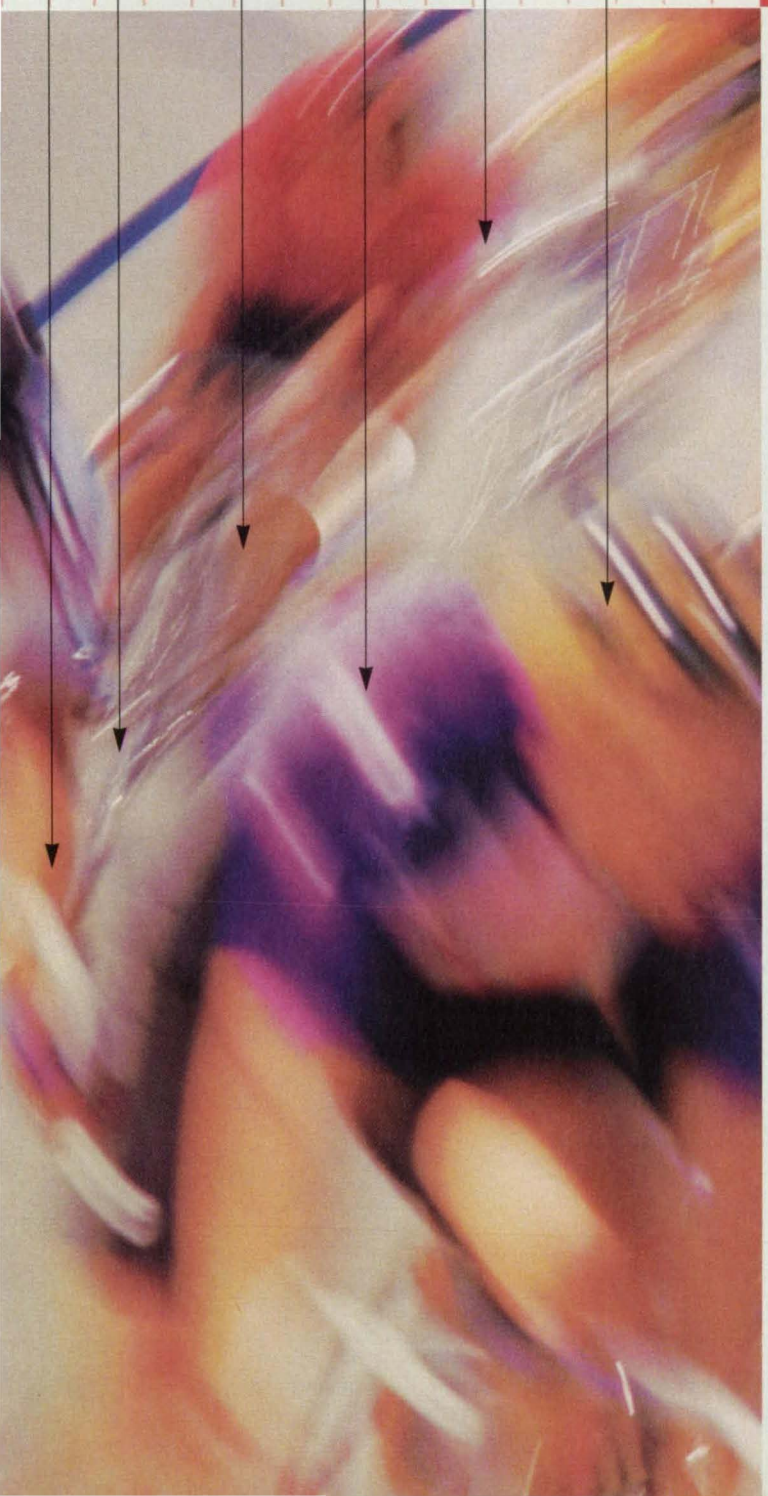

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can be used to shut down the crystal-growth furnaces automatically. The sensor can be incorporated into the cartridge in various ways; for example, it can be affixed to the outer wall of the ampoule or to the inner wall of the cartridge by mechanical mounting or by vapor deposition.

This work was done by Dale A. Watring and Martin L. Johnson of **Marshall Space Flight Center**. *For further information,* ***write in 5*** *on the TSP Request Card. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28852.*

Steerable Capacitive Proximity Sensor

The position of maximum sensitivity can be adjusted without moving the sensor.

Goddard Space Flight Center, Greenbelt, Maryland

Figure 1 illustrates a steerable capacitive proximity sensor of the "capaciflector" type. It is based partly on the capaciflector sensing units described previously in "Capacitive Proximity Sensor Has Longer Range" (GSC-13377), *NASA Tech Briefs*, Vol. 16, No. 8 (August 1992), page 22, and "Capacitive Proximity Sensors With Additional Driven Shields" (GSC-13475), *NASA Tech Briefs*, Vol. 17, No. 11 (November 1993), page 40. The configuration of the electric field of each of those older units is fixed in such a way that the unit is maximally sensitive when the proximate object to be sensed is located somewhere along a line that extends out from the sensor, approximately perpendicular to the surface on which the sensor is mounted. In this unit, the configuration of the electric field can be adjusted in such a way as to make the unit maximally sensitive along a line that is tilted with respect to the perpendicular.

Like the older capaciflectors, this one includes a sensing electrode and driven shields. As explained in more detail in the noted prior articles, the sensing electrode is part of an oscillator, the frequency of which varies with the capacitance between this electrode and the ground of the oscillator circuit. An object that enters the electric field of the sensing electrode alters this capacitance. The resulting change in frequency is measured and taken as an indication of proximity of the object. If, for example, the capaciflector is mounted on a robot arm, the change in frequency could be used as a feedback control signal to prevent the robot from colliding with the object.

Also as explained previously in more detail, the driven shields concentrate the sensing electric field into a narrower space

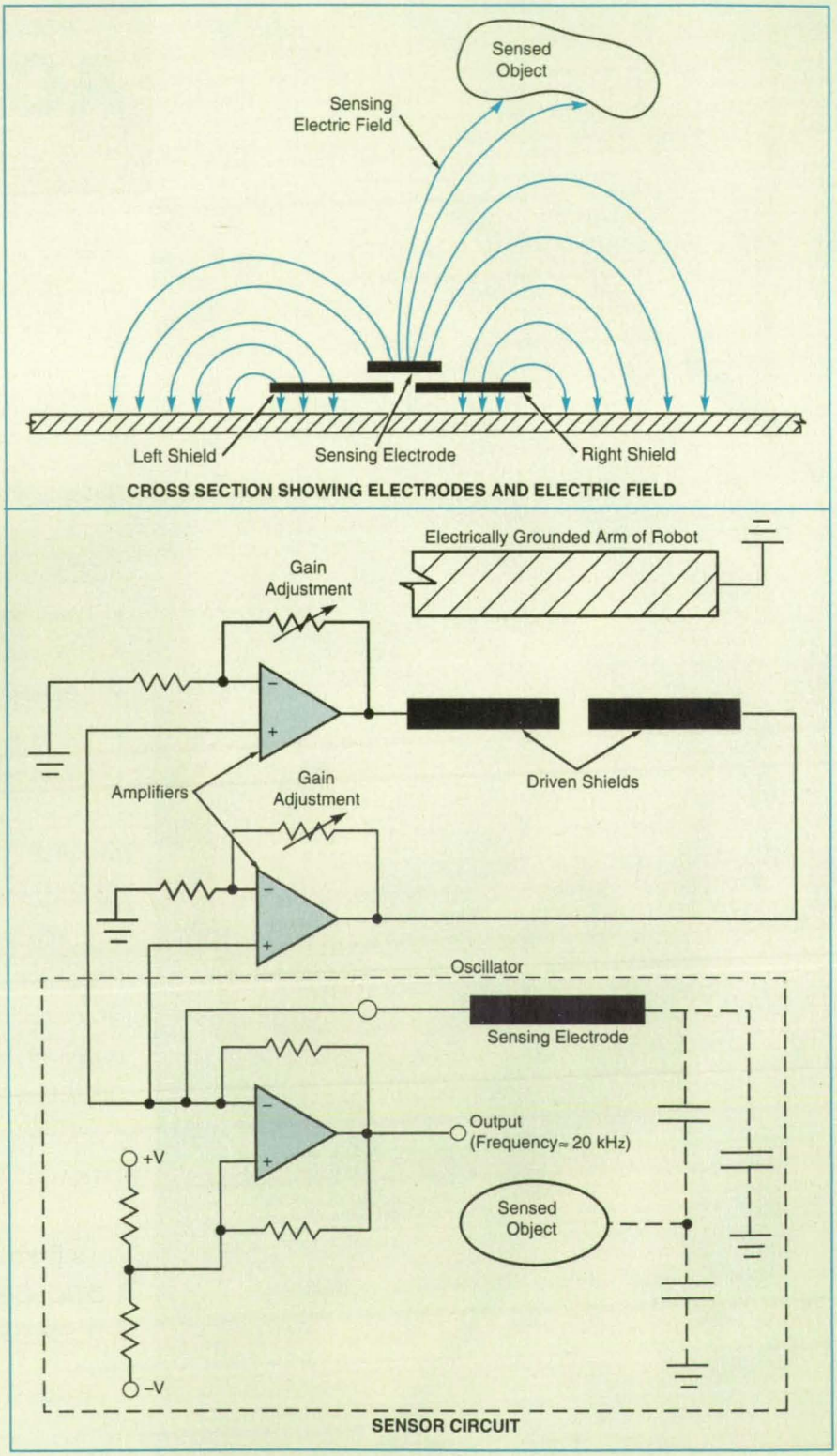

Figure 1. The **Voltage of Each Driven Shield Can Be Adjusted** separately to concentrate the sensing electric field more toward one side or the other.

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projecting outward from the sensing electrode, thereby extending the range and increasing the sensitivity of the unit. The driven shields are connected to the sensing electrode via high-input-impedance voltage amplifiers so that they do not load the oscillator circuit and thus do not alter its frequency.

The novel aspect of this unit is that it includes two or more side-by-side driven shields, each driven via a separate voltage amplifier at an adjustable voltage and extending outward from under the sensing electrode at one side. The gain of each voltage amplifier and thus the voltage on each driven shield can be changed by adjustment of the variable resistors. The configuration of the sensing electric field is altered by a change in the voltages on the driven shields. For example, increasing the voltage on the right shield relative to that on the left shield concentrates the electric field more on the right side, thus tilting the line of maximum sensitivity to the right (see Figure 2).

This work was done by Del T. Jenstrom of **Goddard Space Flight Center** *and Robert L. McConnell of the University of West Virginia. For further information,* ***write in 104*** *on the TSP Request Card.*

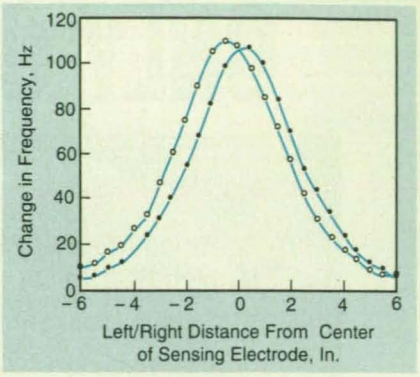

Figure 2. These **Measurements Taken on a Prototype** of the steerable capacitive sensor confirm that significant steering of the sensing electric field is achieved.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 20]. Refer to GSC-13489.

Cryogenic Multichannel Pressure Sensor With Electronic Scanning

Measurements are automatically corrected for temperature from 77 to 373 K.

Langley Research Center, Hampton, Virginia

An array of pressure sensors operates reliably and repeatably over a wide temperature range, extending from the normal boiling point of water (373 K) down to the boiling point of nitrogen (77 K). The sensors are accurate and repeat to within 0.1 percent, so they can operate for 12 months without need for recalibration. The array is scanned electronically, the sensor readings are multiplexed and sent to a desktop computer for processing and storage. The array is used to measure distributions of pressure in research on boundary layers at high Reynolds numbers, which are achieved by use of low temperatures.

The array consists of silicon sensors on a substrate of low-thermal-expansion glass. Each sensor is made from a silicon chip that measures 0.1 by 0.1 in. (2.54 by 2.54 mm). Each chip has been micromachined to form a very thin silicon diaphragm, and four piezoresistive elements have been deposited on the diaphragm in a Wheatstone-bridge configuration.

Each chip is positioned over a hole in the substrate. The external pressure thus exerts itself on the diaphragm, distorting the elements of the Wheatstone bridge and altering the output of the bridge proportionally. The output of the bridge is sampled periodically by a multiplexer and sent to an instrumentation amplifier, both of which are mounted on a printed-circuit card in the same package that contains the arrays of sensors. The output of the instrumentation amplifier is fed to the computer.

On the periphery of each sensor chip is a resistor that responds to temperature of the individual sensor, but not to strain. This resistor provides a reading of the temperature of the chip so that thermally induced offset drift and sensitivity variations in the output of the sensor can be corrected individually for each chip. Like the bridge, the temperature sensor is connected to the multiplexer. The external computer controls the multiplexer so that it scans the pressure and temperature sensors on all chips.

The chips are mounted on the glass substrate by electrostatic bonding. The substrate is prepared by sputtering a layer of tungsten and titanium followed by a layer of gold, then patterned by standard photolithography. A 0.025-in. (0.64-mm) pressure orifice is drilled at the location to be occupied by each sensor.

The chips and substrate are loaded in a fixture that aligns the chips over the holes. Springs on the fixture press the chips firmly against the glass substrate. The fixture and its contents are heated to 380 °C in a vacuum; when the temperature has reached equilibrium, a potential of 800 Vdc is applied to electrodes in the fixture for 5 min, causing elecrostatic bonding between the sensor chips and the glass substrate.

The substrate and chips are removed from the furnace. Then, the substrate is adhesively bonded to a low-thermal expansion alloy pressure-tube plate, the pressure orifices of which are aligned with those in the substrate. The multiplexer chips are mounted with epoxy and connected to the sensor chips via gold wires. The amplifier circuit card makes contact with the sensing substrate via spring-loaded, gold-plated contacts aligned with gold contact pads on the sensing substrate.

This work was done by Purnell Hopson, Jr., John J. Chapman, and Nancy M. H. Kruse of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning license for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-15062.

Electronically Variable Resistive Load

Features include high power, modularity, speed, and capability to dissipate high power.

Lewis Research Center, Cleveland, Ohio

An electronically variable linear resistive load circuit has been synthesized by use of analog components to control the conductance of power metal oxide/semiconductor field-effect transistors (MOSFET's). The circuit has a modular configuration, in which a single controller drives parallel load units. A 3-kW load module that exhibits a submicrosecond response time with respect to the control signal has been demonstrated.

Such loads are useful for the control of certain constant-power generating systems and for transient or stability testing of various power-conditioning and -conversion systems. In comparison with stepped control of loads synthesized by digital switching of discrete resistors, the control of resistance afforded by this circuit is very smooth. This control is faster than is control by pulse-width modulation and follows a precise, device-independent rule enforced by feedback.

The top part of Figure 1 shows the principle of operation to be that of a controlled current regulator driven by a signal proportional to the product of the source voltage (V) and the control signal (V_c). In normal operation, with the MOSFET not saturated, the operational amplifier enforces the equality $IR_s = kV_cV$, where I is the load current, as sensed by R_s, and k is a constant. Therefore, this circuit appears to the power source as a resistor of value $R \equiv V/I = R_s/(kV_c)$. The series resistor R_L serves to limit the power dissipation in the MOSFET load to

$$\frac{V^2}{4(R_L + R_s)}$$

which is useful to ensure safe operation for a given maximum V. Note that R_L is by far the dominant part of the minimum possible R (given by $R_{min} = R_L + R_{DS,on} + R_s$) inasmuch as the current-sensing resistance (R_s) and the on-state resistance ($R_{DS,on}$) of the power MOSFET are usually only fractions of an ohm.

A prototype of the circuit was built with a Burr–Brown type MPY634BM wideband analog multiplier and a type 3554BM fast-settling operational amplifier as the gate driver. Two 350-V load units, each as shown at the bottom of Figure 1, were constructed on water-cooled, copper baseplates and connected in parallel to the same driver through coaxial cables 2 ft (0.6 m) long. The power components in each load unit are two 250-W MOSFET's and three noninductive, aluminum-housed 200-Ω resistors. Also included are 0.5-Ω resistors in the source leads to improve current balance in the parallel MOSFET's and ferrite beads to suppress any tendency for the transistors to oscillate in a circular mode.

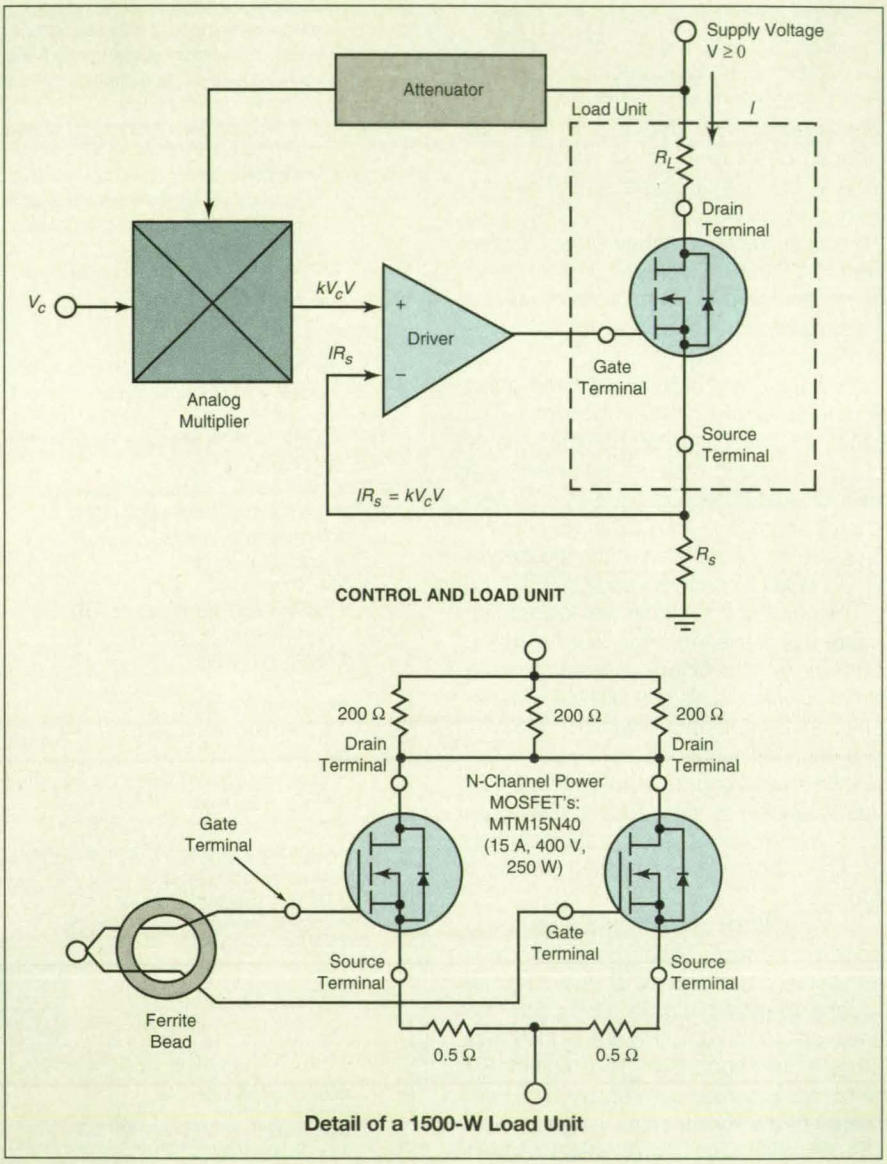

Figure 1. The **Electronically Variable Load Circuit** presents a synthesized linear resistive load to the power supply. Power is dissipated in the load unit. Load units are modular; several can be connected in parallel to increase power-dissipating capacity.

Figure 2 illustrates the large-signal response observed when using the two load units described above. With the source fixed at 350 V, the load current shown in the upper pair of traces rises at

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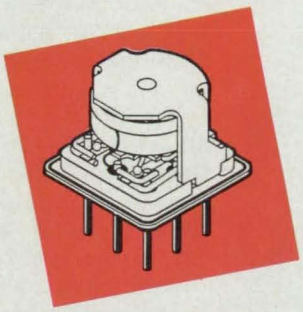

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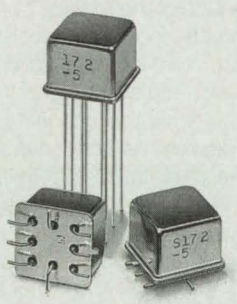

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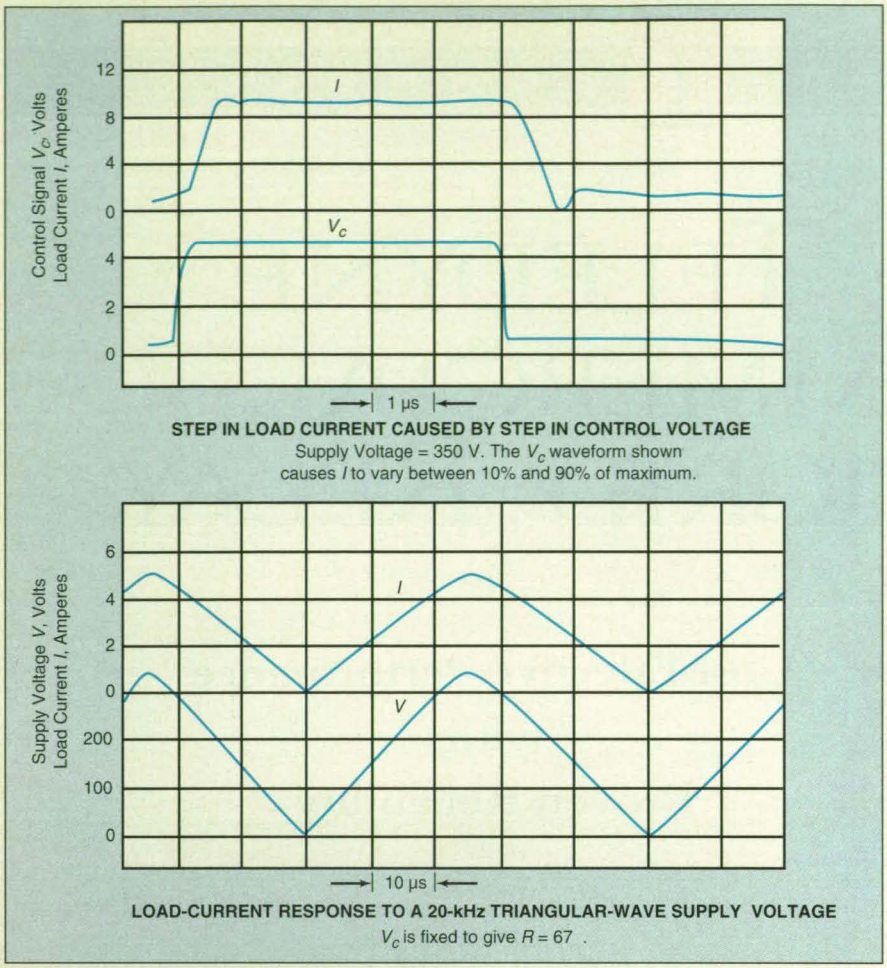


Figure 2. The **Load-Current Responses** to selected control-signal and supply-voltage waveforms are shown in these oscilloscope traces.

about 16 A/μs in response to a step in V_C. Experiments showed that this circuit has good bilinearity in V_C and V, as is desirable in control-loop applications. The lower pair of traces shows load current observed in response to a 20-kHz triangular source V, with V_C fixed to give R = 67 Ω. When a 1-kHz triangular-wave input was used for either V_C or V, the load-current and input waveforms were indistinguishable on an oscilloscope.

One potentially useful, although untested, modification of this circuit would be the substitution of static induction transistors (SIT's) for the MOSFET's to get higher specific power, speed, and radiation hardness. Another variant circuit would dissipate a constant power, as set by V_C, regardless of the variations of V within some bounded range; to implement such a circuit, one would have to reconfigure the analog multiplier to form the quotient V_C/V instead of the product V_CV.

This work was done by Janis M. Niedra of Sverdrup Technology, Inc., for **Lewis Research Center**. *Further information may be found in NASA CR-187155 [N91-27446/TB], "Analog Synthesized Fast-Variable Linear Load."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. LEW-15686.

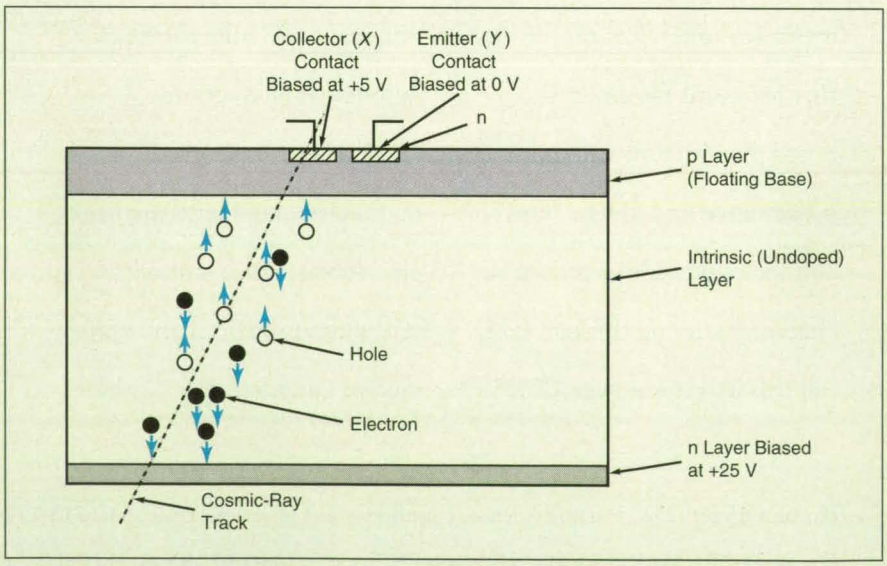
Active-Pixel Cosmic-Ray Sensor

Advantages would include simpler structure and greater sensitivity.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed cosmic-ray sensor would comprise a planar rectangular array of lateral bipolar npn floating-base transistors (see figure), each of which would define a pixel. The collector contacts of all transistors in each row would be connected to the same X (column) line conductor; the emitter contacts of all transistors in each column would be connected to the same Y (row) line conductor; and the current in each row and column line would be sensed by an amplifier, the output of which would be fed to signal-processing circuits. Thus, a cosmic-ray hit in a given pixel would give rise to currents in the X and Y lines connected to it. The location of the hit would thus be known to within the pixel resolution, and the sizes of the currents would be indicative of the energy of the impinging cosmic ray.

One of the advantages of the proposed design is that the floating-base transistor



The **Floating-Base Transistor** in each pixel would both detect and amplify the charge of holes that traveled to the base from the cosmic-ray track.

in each pixel would not only collect the signal but would also buffer and amplify the signal for readout. Each impinging cosmic ray would generate electrons and holes in the intrinsic layer, among other places. Holes would flow toward the floating base, raising the base voltage by approximately $DV_{base} = Q_{sig}/C_{base}$, where Q_{sig} is the signal charge of holes that reach the base and C_{base} is the capacitance of the base. This increase in base voltage would cause the transistor to turn on and current to flow between the collector and the emitter. The current flowing into the collector would be sensed by the amplifier connected to the row conductor, and the current flowing out of the emitter would be sensed by the amplifier connected to the column conductor. Because the collection of charge carriers anywhere in the base would lead to the same increase in base voltage, the signal generated on the row and column conductors would be independent of the position of the particle track within the pixel.

If the gain of the bipolar transistor were b, and the Q_{sig} flowed in as a current i_{sig}, then to first order, the signal out of the transistor would be $i_{ce} = \beta i_{sig}$; that is, the transistor action would amplify the signal by a factor of b. The bipolar transistor would also buffer the signal such that the capacitance to sense the signal charge Q_{sig} would remain only C_{base}, regardless of the size of the array. In contrast, the pixel capacitance of an $N \times N$-pixel array of a prior developmental cosmic-ray sensor array containing positive/intrinsic/negative silicon devices is approximately NC_{base}. Thus, overall, the sensitivity of the proposed sensor would be about bN times that of the prior sensor. Also in comparison with the prior sensor, the proposed sensor is expected to be fabricated in greater yield and to be more readily scalable to smaller pixels, lesser thicknesses, and greater numbers of pixels.

This work was done by Eric R. Fossum, Thomas J. Cunningham, and Melinda J. Holtzman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 7*** *on the TSP Request Card. NPO-18975.*

Computing Scattering Characteristics of Waveguide Junctions

A waveguide device is modeled as an assembly of rectangular waveguides of different cross sections.

NASA's Jet Propulsion Laboratory, Pasadena, California

To optimize frequency responses of waveguides and determine the tolerances required to meet radio-frequency specifications, accurate computer modeling of passive rectangular waveguide components is often needed. Many rectangular waveguide components can be represented either exactly or approximately as a number of rectangular waveguides of different sizes connected in series.

The Rectangular WaveGuide Junction SCATtering (RWGSCAT) computer program solves for the scattering properties of a waveguide device. The device must consist of a number of rectangular waveguide sections of different cross-sectional areas connected in series. Devices that fall into this category include step transformers, filters, and smooth or corrugated rectangular horns.

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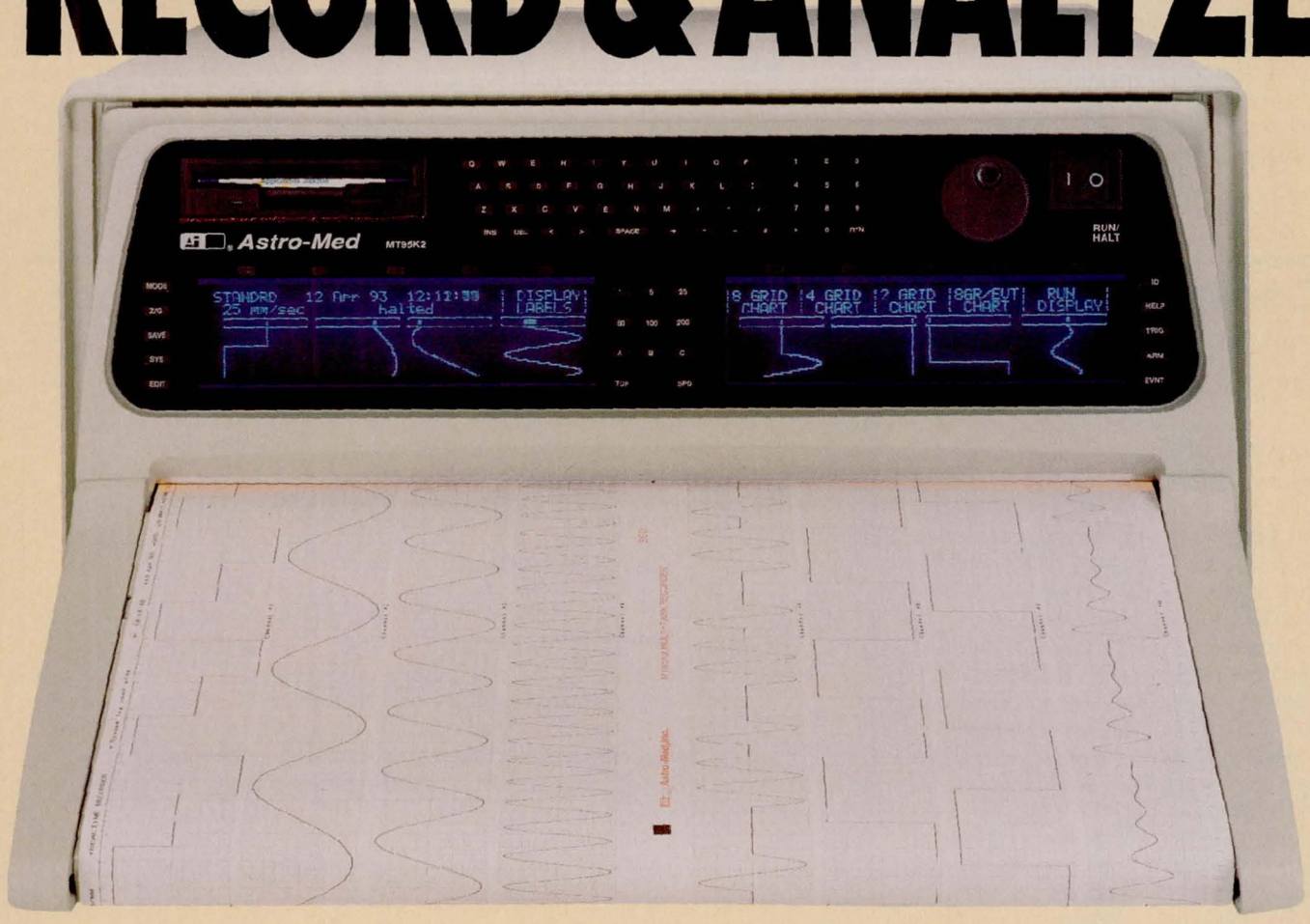

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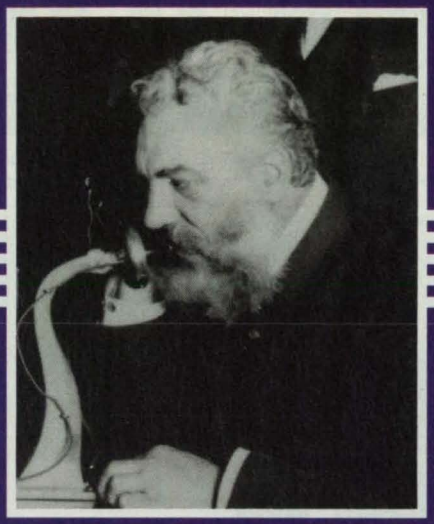

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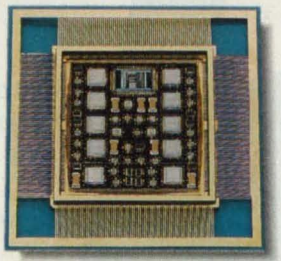

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RWGSCAT models such devices and accurately predicts the reflection and transmission characteristics, taking into account higher-order (other than dominant TE_{10}) mode excitation if it occurs, as well as multiple reflections and energy stored at each discontinuity. In the case of a device that is large with respect to the wavelength of operation, the characteristics of the device may be required for computing a higher-order mode or a number of higher-order modes that excite the device. Such interactions can be represented by defining a scattering matrix for each discontinuity in the device, and then cascading the individual scattering matrices to determine the scattering matrix of the overall device. The individual matrices are obtained by use of the mode-matching method.

RWGSCAT is written in FORTRAN 77 for IBM PC-series and compatible computers running MS-DOS. It has been successfully compiled and implemented by use of Lahey FORTRAN 77 under MS-DOS. A sample MS-DOS executable code is provided on the distribution medium. It requires 377K of random-access memory for execution. Sample input data are also provided on the distribution medium. The standard distribution medium for this program is one 5.25-in. (13.34-cm), 360K MS-DOS-format diskette. The contents of the diskette are compressed by use of the PKWARE archiving software tools. The utility program to unarchive the files, PKUNZIP.EXE, is included. An electronic copy of the documentation is included on the distribution medium in Latex format. RWGSCAT is also offered as a bundle with a related program, CWGSCAT (Scattering Matrix Program for Circular WaveGuide Junctions). Please see the abstract for RWGSCAT/CWGSCAT (COS-10045) for information about the bundled package. RWGSCAT was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

This program was written by Daniel J. Hoppe and Farzin Manshadi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 16*** *on the TSP Request Card. NPO-19091.*

Constant-Delay Broadband Microwave Phase Modulator

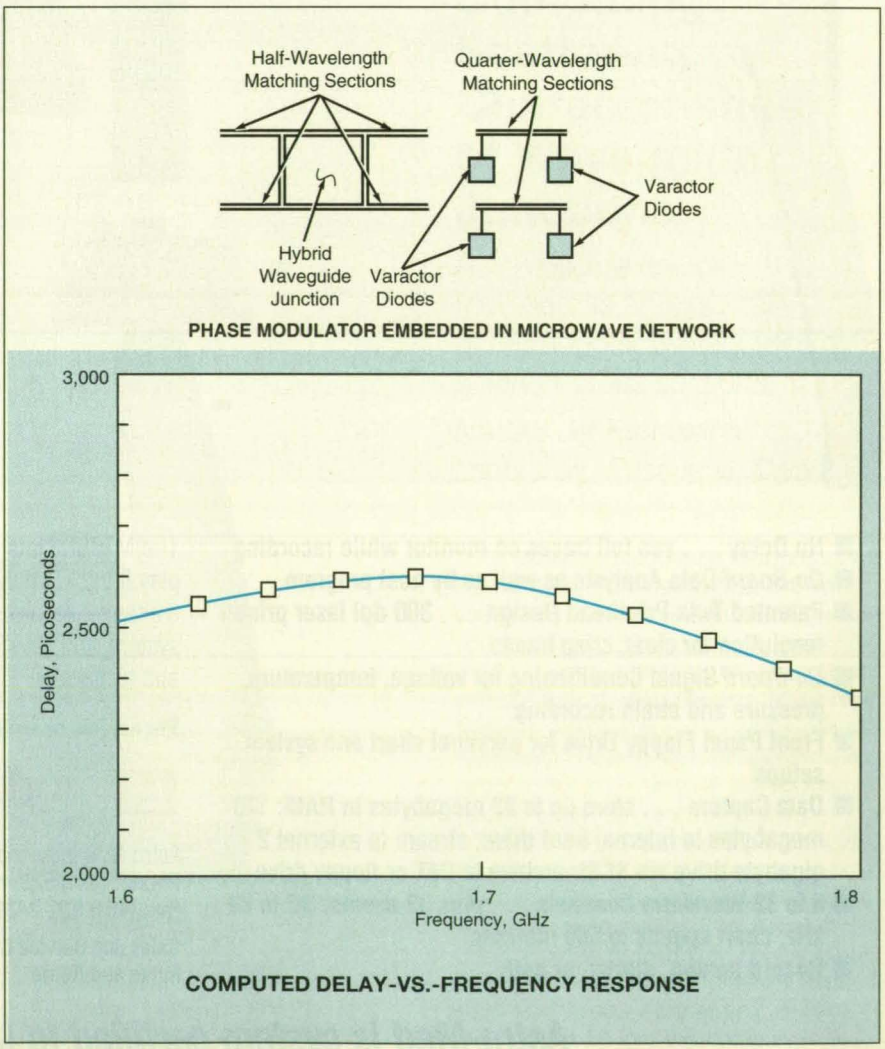
Varactor diodes and transformer waveguide sections are used instead of tuned circuits.

Goddard Space Flight Center, Greenbelt, Maryland

The figure illustrates schematically the essential radio-frequency components of a microwave phase modulator embedded in a waveguide network and designed to achieve nearly constant delay over the frequency band from about 1.6 to about 1.8 GHz. In the phase modulator, a hybrid waveguide junction is terminated at two of its ports with half-wavelength sections of waveguide coupled to pairs of varactor diodes separated by quarter-wavelength sections of waveguide. These varactor/waveguide terminating structures play the same role as lumped-parameter resonant circuits would: they provide, in principle, total reflection at the desired resonant frequency.

The design of the phase modulator is based partly on the principle that if impedances are matched at all ports of the hybrid junction, then the overall microwave network acts as a broadband coupler. Some of the needed impedance matching is performed by the quarter-wavelength sections between the varactor diodes, and some by half-wavelength sections. The impedances of the half- and quarter-wavelength matching sections must be chosen along with the junction capacitance (and thus, the radio-frequency impedance) of the varactor diodes at the operating dc bias level: these design parameters are chosen iteratively with the help of a microwave-design computer program.

This work was done by Mark Francisco and Krishna Praba of **Goddard Space Flight Center**. *For further information,* ***write in 64*** *on the TSP Request Card. GSC-13253.*



The **Microwave Phase Modulator** would exhibit approximately flat delay-vs.-frequency response in the frequency band of interest, according to design computations.

Integrated-Circuit Controller for Brushless dc Motor

Size, weight, and power consumption can be smaller than those of other controllers.

Marshall Space Flight Center, Alabama

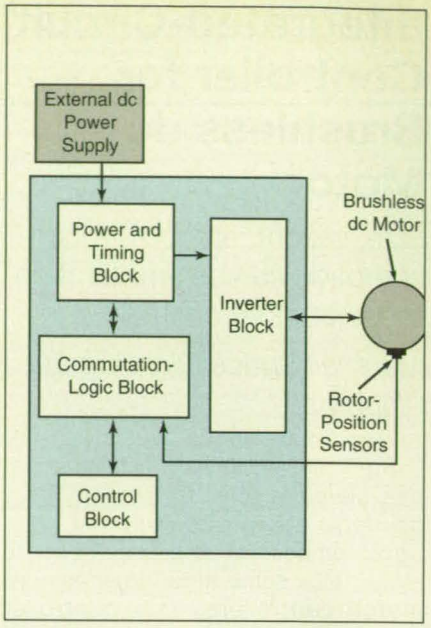
The figure illustrates a generic circuit that performs most of the commutation-logic and power-switching functions for control of a brushless dc motor. Like some other brushless-dc-motor controllers, this controller includes (1) commutation-logic and associated control circuitry that generates commutation commands in response to the outputs of rotor-position sensors and to externally supplied speed and direction commands, (2) a power supply, and (3) inverters containing power transistors, which commute power to the stator windings of the motor in response to the commutation commands. The major advantages of this controller are that its size, weight, and power consumption can be made less than those of other brushless-dc-motor controllers.

Several versions of the controller were at various stages of development when the information for this article was submitted. A "breadboard" prototype comprises an assembly of commercial integrated circuits and discrete components. A more advanced low-power monolithic version incorporates all functions on a single integrated-circuit chip; medium and high-power versions are expected to incorporate low-power circuitry (logic and associated control circuitry) on main controller chips and higher-power circuitry (power-supply and inverter circuitry) on external chips and/or implemented off chip with discrete analog components.

The commutation-logic block can operate the motor in either two or four quadrants. In two-quadrant operation, the commutation signals are timed so that power is delivered to the stator windings to maintain rotation at the externally commanded speed or motor current in the externally commanded direction. In four-quadrant operation, the motor can be both driven and braked in either direction; in the braking mode, the commutation signals are timed to extract power (via back-

electromotive force) from the stator windings; the power is ordinarily returned to the power supply, except that when it exceeds a threshold beyond which it could damage the power supply, the excess is dissipated in a built-in load resistor.

The control block performs the feedback control functions for maintaining the commanded speed, direction, and motor current. In two-quadrant operation, this block closes the current-feedback loop; in four-quadrant operation, the current-feedback loop is closed by an external microprocessor and/or discrete components. The control block includes built-in monitoring circuitry that detects position-sensor failures and overcurrent in the motor. The control block also includes a dead-time generator, which provides a programmable dead time between the nominal "on" periods of the switching power transistors of the inverter paired in series across the isolated power supply: This dead time is necessary because without it, the finite switching times of these transistors could cause them to be on simultaneously (forming a short circuit across the power supply) during brief overlaps between their alternating nominal "on" and "off" periods — a phenomenon called "shoot-through."



The **Controller for a Brushless dc Motor** can be fabricated as a single integrated-circuit chip (at least in low-power versions).

The power and timing block provides a power supply that is partly isolated, with a ground-reference low side and a floating high side. It isolates the power transistors of the inverter block from the commutation-logic block. The power and timing block includes ground-reference predrive stages that drive the low-voltage-side power transistors of the inverter block and level shifting predrive stages (which have floating outputs) that drive the high-voltage-side power transistors of the inverter block.

This work was done by Dong Tuan Le of Allied-Signal Aerospace Co. for **Marshall Space Flight Center**. *For further information,* ***write in 44*** *on the TSP Request Card.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Allied-Signal Aerospace Co.

Inquiries concerning licenses for its commercial development should be addressed to:

Allied-Signal Aerospace Co.
Attn: Hugh P. Gortler
Patent Attorney
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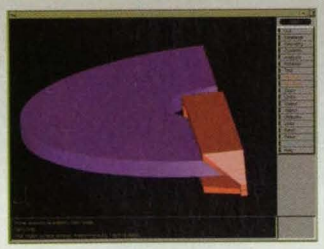

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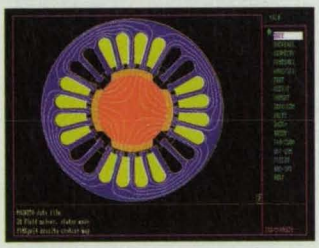

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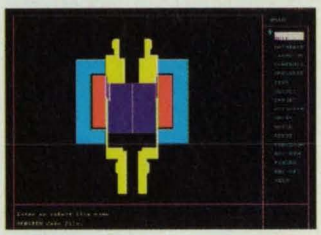

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Multilayer Microstrip Slot and Dipole Array Antenna

Interleaved arrays transmit and receive in different polarizations at different frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A multilayer antenna structure schematically shown in the figure contains interleaved linear subarrays of microstrip dipole and slot radiating antenna elements to provide a compact, dual-band antenna. The structure also contains the associated microstrip transmission lines, plus high-power amplifiers for transmission and low-noise amplifiers for reception. The overall function of this antenna structure is to transmit in horizontal polarization at a frequency of 29.634 GHz and receive in vertical polarization at 19.914 GHz, in a direction 44° from broadside to the antenna. This antenna structure is part of the apparatus described in "Steerable K/Ka-band Antenna for Land-Mobile Satellite Applications" (NPO-18772), *NASA Tech Briefs*, Vol. 18, No. 1, (January 1994), page 28.

The input signal to be transmitted is first distributed to the high-power amplifiers via a power-dividing beam-forming network. The dipoles are series-fed via electromagnetic coupling from microstrip transmission lines connected to the output terminals of the high-power amplifiers.

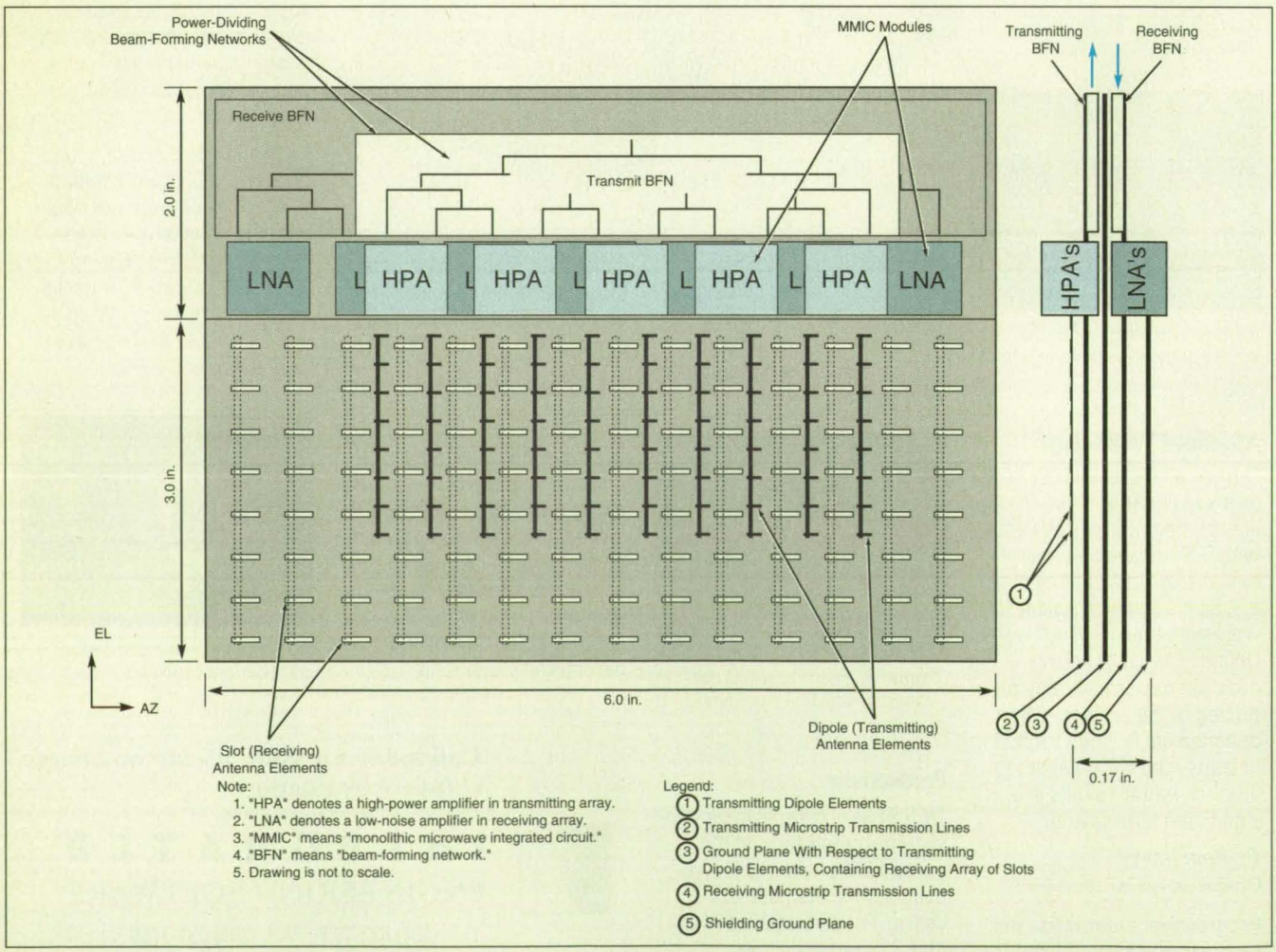
The same planar conductor that serves as the ground plane for the dipole (transmitting) antenna elements also contains the slot (receiving) antenna elements. The slots are electromagnetically coupled to a second set of microstrip transmission lines on the underside of the slotted ground plane in a series-fed arrangement similar to that of the dipoles. These transmission lines couple the received signals to the low-noise amplifiers, the outputs of which are combined in a second beam-forming network. Inherently good isolation is expected between the receive and transmit signals since the corresponding circuitry are on opposite sides of the primary antenna ground plane.

The design of the linear series-fed-type arrays is achieved using transmission-line theory with equivalent circuit models for the radiating elements. The element offsets and interelement line lengths are used to obtain the desired amplitude distribution and beam direction, respectively.

This work was done by Ann N. Tulintseff of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 75*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: William T. Callaghan, Manager; Technology Commercialization; (M/S 79-23); Jet Propulsion Laboratory; 4800 Oak Grove Drive; Pasadena, CA 91109.

Refer to NPO-18837 volume and number of this NASA Tech Briefs issue, and the page number.



Interleaved Arrays of Dipole and Slot Elements transmit and receive in horizontal and vertical polarization, respectively, at 29.634 and 19.914 GHz, respectively.

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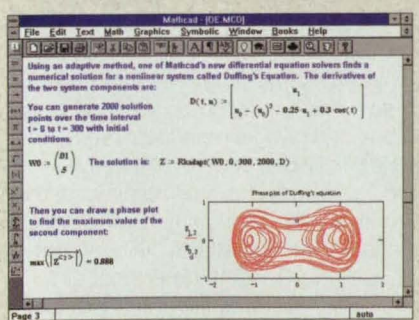

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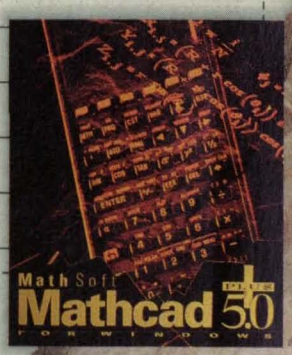

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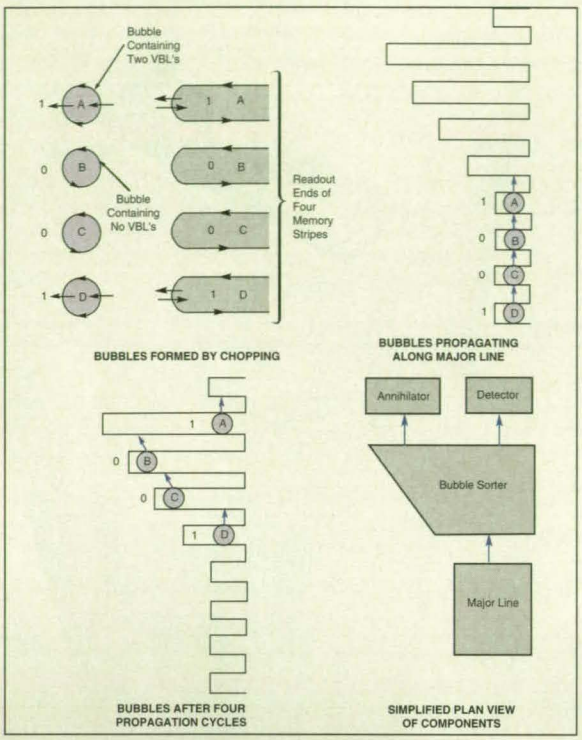
For More Information Write In No. 650

Improved Reading Gate for Vertical-Bloch-Line Memory

Reliability of detection of data bits is increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved design for the reading gate of a vertical-Bloch-line magnetic-bubble memory increases the reliability of discrimination between binary ones and zeros. In the prior design, discrimination between a one and a zero at a given location in a magnetic-bubble memory depended on the application of magnetic-stripe-chopping electrical currents of various magnitudes and the detection of the presence or absence of the resulting magnetic bubble. The prior design was unreliable in that the differences between the amplitudes of chopping currents that produced "one" and "zero" magnetic-bubble readouts were small (sometimes even nonexistent) and dependent on the magnetic substrate material. The improved design does not involve discrimination between substrate-dependent chopping-current amplitudes; instead, current sufficient to chop any magnetic bubble is applied, and discrimination between ones and zeros is effected by a more-reliable bubble-propagation scheme.



Magnetic Bubbles that signify binary "1" and "0" are produced by applying sufficiently large chopping currents to memory stripes. The bubbles are then propagated differentially in the bubble sorter. This method of discriminating between ones and zeros is more reliable than is the prior method based partly on differences between amplitudes of chopping currents.

The principle of operation of a vertical-Bloch-line magnetic-bubble memory was described in "Vertical-Bloch-Line Memory" (NPO-18467), *NASA Tech Briefs*, Vol. 17, No. 6 (June 1993) page 42. To recapitulate: The storage medium is a magnetic substrate delineated into stripes that constitute magnetic domains, the bulk of the substrate is magnetized perpendicularly to the plane of the substrate, and the stripes are also magnetized perpendicularly to the plane but in the opposite direction. A vertical Bloch line (VBL) is a twist in the magnetization in the Bloch wall (the boundary of the domain) in the plane. Two such twists of the same chirality at the same location constitute a VBL pair. The presence or absence of a VBL pair at a given bit-cell location represents a binary one or zero, respectively.

The figure illustrates the improved readout as it applies to four memory stripes that contain the bit pattern "1001." Where a VBL pair (signifying "1") is present at the chopping conductor at the end of a stripe, the application of the chopping current is sure (because the amplitude of the current is set large enough) to produce a magnetic bubble that contains two VBL's; this is the case for stripes *A* and *D*. Where no VBL pair is present (signifying "0"), the application of the chopping current produces a magnetic bubble that contains no VBL; this is the case for stripes *B* and *C*.

The magnetic bubbles are propagated along a dual-meandering-conductor track called a "major line" and into an end portion of the major line that tapers to a greater width. The end portion is called the "bubble sorter," and bubbles are sorted there by use of gyrotropic deflection of the bubble-propagation path; each bubble that contains two VBL's (binary "1," bubbles *A* and *D*) propagates along the gradient of the magnetic field. Each bubble that contains no VBL's (binary "0," bubbles *B* and *C*) propagates at about 45° with respect to the gradient of the magnetic field. Thus, after four propagation cycles, the "0" bubbles *B* and *C* lie to the left of the "1" bubbles *A* and *D*. The bubble detector is placed in line with the straight propagation path to detect the two-VBL ("1") bubbles. A bubble annihilator is placed in line with the 45° propagation path to collapse the no-VBL ("0") bubbles.

This work was done by Jiin-Chuan Wu, Henry L. Stadler, and Romney R. Katti of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 80*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: illiam T. Callaghan, Manager; Technology Commercialization; Jet Propulsion Laboratory; (M/S 301-350); 4800 Oak Grove Drive; Pasadena, CA 91109.

Refer to NPO-18615, volume and number of this NASA Tech Briefs *issue, and the page number.*

Square-Spiral Microstrip Antennas

The square shape may simplify fabrication.

Langley Research Center, Hampton, Virginia

Square-spiral microstrip antennas for wideband reception at frequencies of several gigahertz have been proposed. Like other microstrip antennas of both spiral and nonspiral shape, these could be made to conform to surfaces of aircraft and other vehicles. Also like other microstrip antennas, these would offer the advantage of thinness (about one-tenth the thickness of nonmicrostrip spiral antennas). The square shapes of the spirals in these spiral microstrip antennas may offer an advantage over the curved shapes of the spirals of other spiral microstrip antennas in that the square shapes may simplify fabrication.

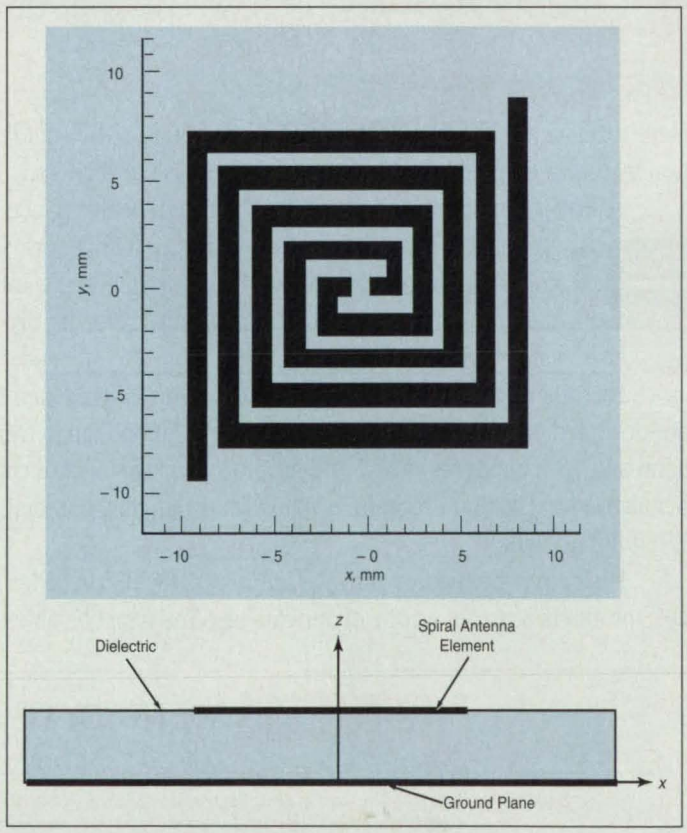


Figure 1. A **Square-Spiral Microstrip Antenna** (as distinguished from spiral microstrip antennas of different shapes) may offer the advantage of simpler fabrication.

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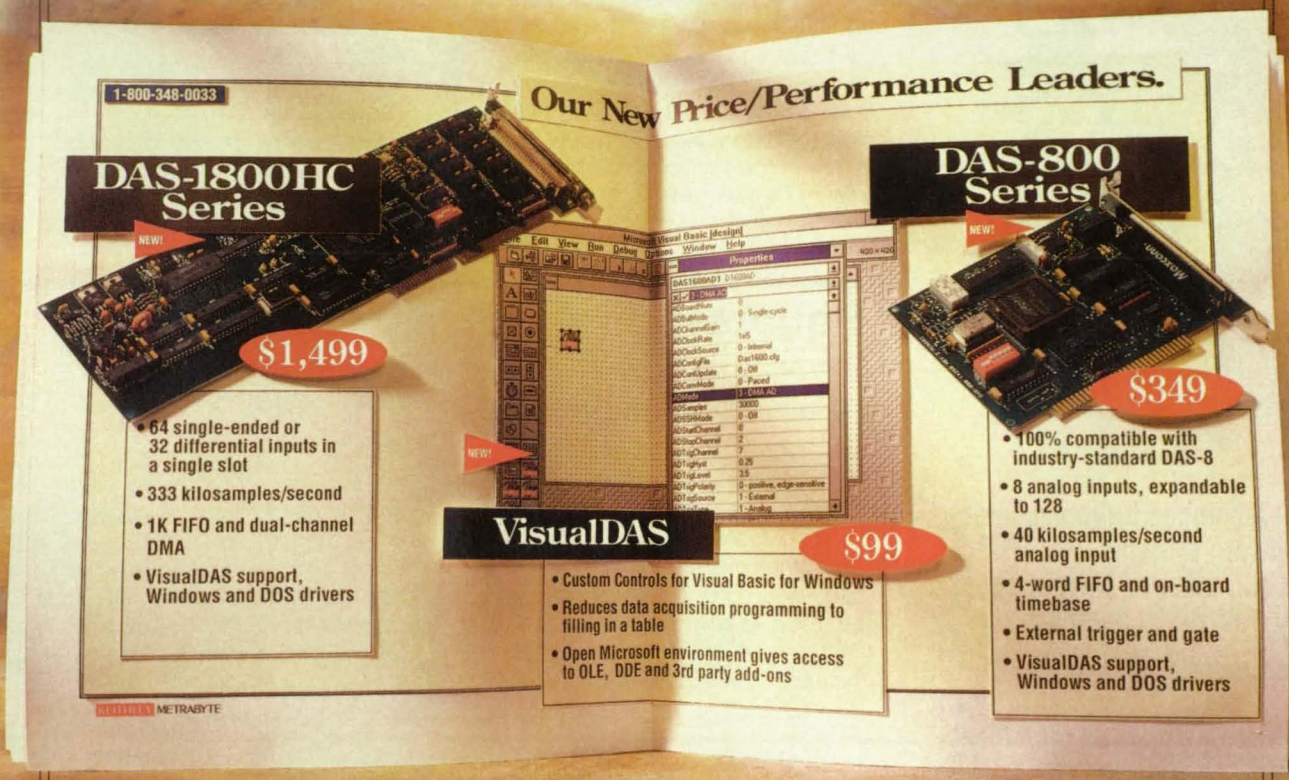

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Figure 1 illustrates a basic square-spiral microstrip antenna, which would comprise a square-spiral conductive strip on a dielectric slab backed by a ground plane. Optionally, resistive materials could be placed on the arms of the spiral to enhance performance by absorbing energy in unwanted higher-order electromagnetic modes. Optional dielectric layers above the spiral conductor could also be added.

The performance of the antenna shown in Figure 1 was computed, starting by use of a spectral-domain Green's function for a current element on a dielectric slab to develop an integral equation that could be solved by the method of moments. The antenna was taken to be excited by a voltage generator at the inner ends of the arms of the spiral, and the current density on the spiral was modeled by piecewise-linear subdomain basis functions, the subdomains being small square pieces into which the spiral was subdivided. In this formulation, the effects of the dielectric were modeled rigorously. (This formulation is extendable to arrays of square-spiral microstrip antennas and to dichroic reflector surfaces made of arrays of square-spiral microstrip patches.) Figure 2 shows selected aspects of the computed performance, which com-pares favorably with that of a similar Archimedian-spiral microstrip antenna.

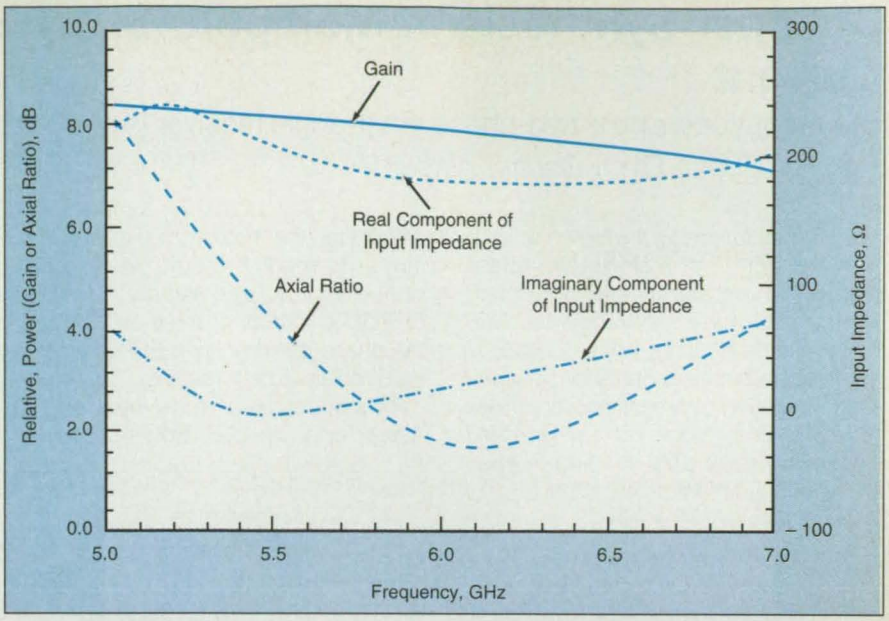


Figure 2. **Some of the Performance Characteristics** of the antenna shown in Figure 1 were computed as a function of frequency.

This work was done by David G. Shively of **Langley Research Center**.

No further documentation is available. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-15088.

Cheaper Synthesis of Multipole-Brushless-dc-Motor Current

The output of a single two-phase shaft-angle resolver is converted to multispeed three phase.

Marshall Space Flight Center, Alabama

The figure illustrates a circuit that converts the output of a single two-phase shaft-angle resolver to that of a multispeed three-phase shaft-angle resolver. The multispeed three-phase output is needed to generate currents for sinusoidal commutation of a multipole brushless dc motor: torque ripple can be minimized by exciting each pole winding in each phase with a current proportional to

$$\sin\left(N\theta + 2\frac{k\pi}{3}\right)$$

were N is half the number of poles; k = 0, 1, or 2, depending on the phase; and θ is the instantaneous angle of the rotor magnets with respect to the stator windings (shaft angle) of the motor.

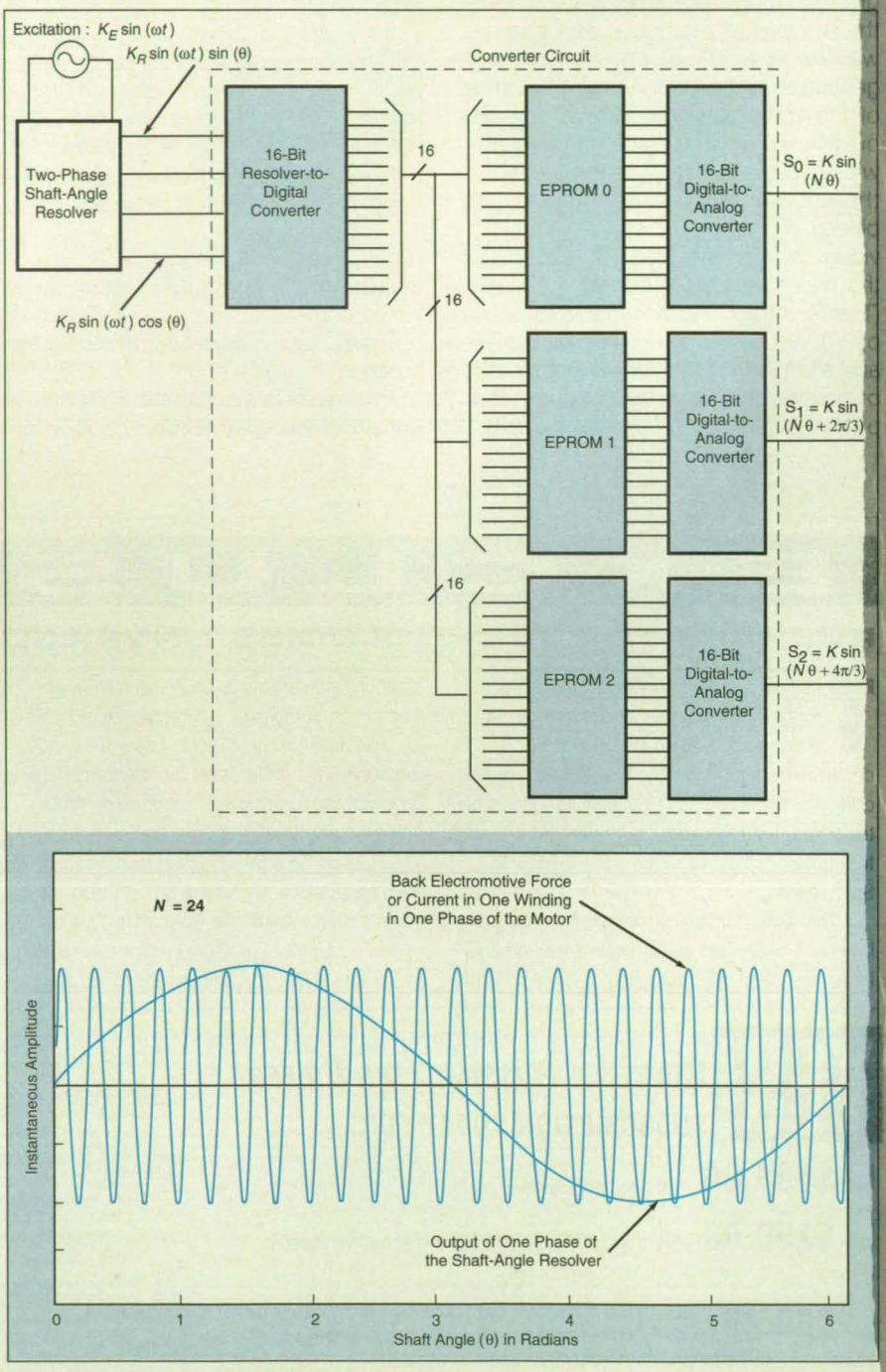
The two-phase shaft-angle resolver is attached to the shaft of the motor and excited at frequency $\mu/2\pi$, so that its two outputs are proportional to sin (μt) sin (θ) and sin (μt) cos (θ), where t = time. These signals are fed to a resolver-to-digital converter, which produces a 16-bit digital word that represents the shaft angle. This word is used to address simultaneously three erasable programmable memory (EPROM) integrated circuits, each of which contains the digitized amplitudes of $N/2$ cycles of a sine wave. The data stored in each EPROM are divided into 64K 16-bit words. The phases of the sine waves in EPROM's 1 and 2 are shifted $2\pi/3$ and $4\pi/3$ radians, respectively, with respect to that of the sine wave in EPROM 0.

The digital amplitudes obtained from the EPROM's are fed to 16-bit digital-to-analog converters, which generate voltages proportional to the required sinusoidal excitations. Thus, the final output of the circuit is a three-phase set of sinusoidal voltages, each of which exhibits N cycles during one rotation of the motor shaft and is synchronized with the rotation.

The concept of this converter circuit is generally applicable to the generation of multispeed, multiphase shaft-angle-resolver signals from a single two-phase shaft-angle resolver. Where $2N$ is large (e.g., 48 in the original application), the combination of this converter circuit and the single two-phase shaft-angle resolver offers significant advantages in that its cost, weight, size, and complexity are less than those of a multispeed, multiphase shaft-angle resolver of similar capability. The design of this converter circuit is readily adaptable to a two-phase motor: one simply uses two EPROM's instead of three and changes the phase shift between EPROM's from $2\pi/3$ radians to $\pi/2$ radians.

This work was done by Dean C. Alhorn and David E. Howard of **Marshall Space Flight Center**. *For further information,* ***write in 26*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28855.



Three-Phase Sinusoidal Signals that undergo N cycles for each complete rotation of the shaft are generated by this circuit from the output of a two-phase shaft-angle resolver.

Electrode/Dielectric Strip for High-Energy-Density Capacitor

Energy density could be double that of a similar commercial capacitor.

NASA's Jet Propulsion Laboratory, Pasadena, California

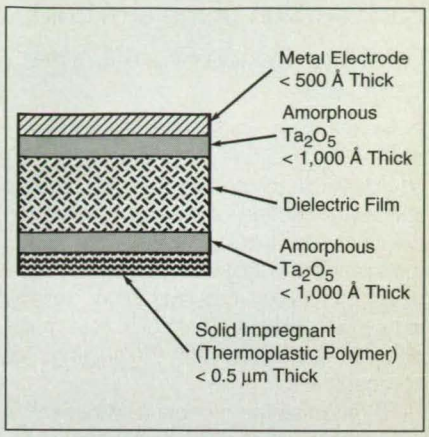
A proposed improved unitary electrode/ dielectric strip would serve as a winding in a high-energy-density capacitor in a pulsed power supply. The strip would offer the combination of qualities essential for high energy density: high permittivity of the dielectric layers, thinness, and unusually high resistance to breakdown of the dielectric at high electric fields. Unlike some capacitors that are now commercially available, capacitors made with the proposed strip material would not be impregnated with liquid; the problem of containing the liquid would be eliminated, and the volume of packaging material would thus be reduced. By virtue of the increased breakdown strength and increased packaging efficiency that would be afforded by the improved unitary electrode/dielectric strip material, it should be possible to achieve an energy density twice that of a commercial capacitor made with the same dielectric film.

The figure illustrates the proposed improved electrode/dielectric strip, which would be formed on a strip of dielectric material like that now used in commercial high-energy-density capacitors [e.g., polyvinylidene fluoride film, which has a dielectric constant of about 11 and a breakdown strength of about 19 kV/mil (about 7.5×10^8 V/m)]. By use of nonreactive or reactive vapor-phase deposition or sputtering, layers of amorphous Ta_2O_5 less than 1,000 Å thick would be deposited on both faces of the dielectric film.

The Ta_2O_5 layers would have low dielectric loss and would offer a desirable combination of high dielectric constant (28), high dielectric breakdown strength (20 kV/mil) (about 7.9×10^8 V/m), and high absorptivity of electric charges injected from the electrode layers to be added subsequently. Inasmuch as the injection of charges from electrodes is a principal factor in the initiation of breakdown of dielectric films, the ability of the Ta_2O_5 layers to reduce the injection of charge would thus increase the effective breakdown strength of the overall sandwich of dielectric layers.

A layer of Al, Zn, or other suitable metal with a thickness < 500 Å would be deposited on one of the Ta_2O_5 layers to form the electrode layer. A solid impregnant layer, with a thickness <0.5 μm, would be deposited on the other Ta_2O_5 layer by solution coating. The solid impregnant would be a thermoplastic polymer with a high dielectric constant (e.g., polyurethane). To fabricate a capacitor, two pieces of unitary electrode/dielectric strip material would be wound into a cylinder, which would be vacuum-bagged and subjected to high isostatic pressure with moderate heating so as to laminate the solid impregnant to the adjacent strip without damaging the dielectric film. After the lamination process, lead wires would be attached to the electrodes, and the cylindrical winding would be encased in a plastic or other suitable material.

This work was done by Shiao-Ping S. Yen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 95*** *on the TSP Request Card. NPO-18912.*



The **Improved Electrode/Dielectric Strip**, shown here in cross section, would include layers of amorphous Ta2O5 to increase breakdown strength by suppressing injection of charges from the electrodes. The solid impregnant would simplify packaging and increase packaging efficiency.

Packaging of Control Circuits in a Robot Arm

Each section of the arm holds command and drive components.

Goddard Space Flight Center, Greenbelt, Maryland

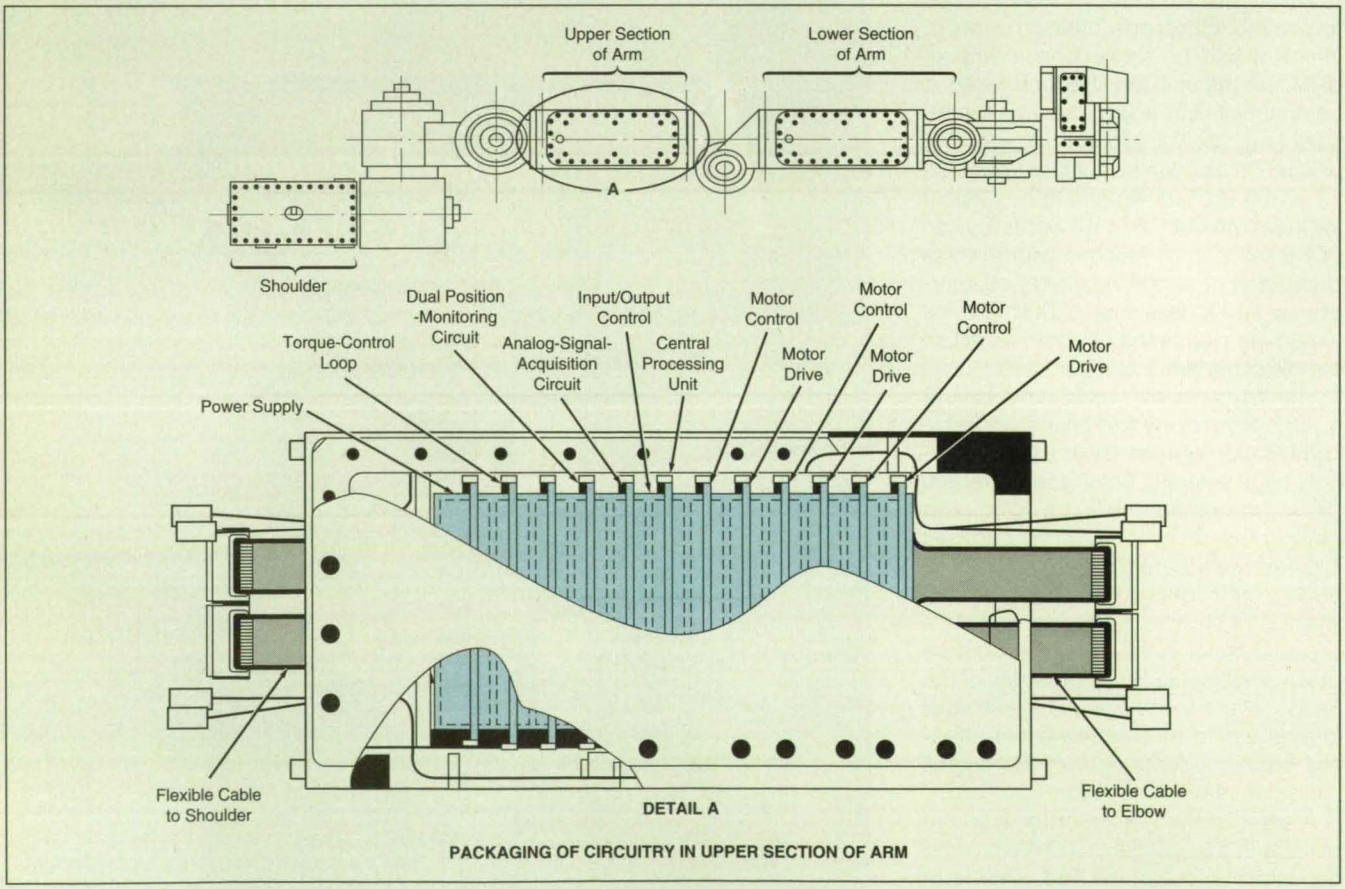
A packaging system houses and connects control circuitry mounted on circuit boards within the shoulder, upper section, and lower section of a seven-degree-of-freedom robot arm. The system has a modular design that incorporates surface-mount technology, multilayer circuit boards, large-scale integrated circuits, and multilayer flat cables between the sections for compactness.

To minimize the number of wires in the cables between sections and thereby prevent the bulk and stiffness of many wires from reducing the dexterity of the robot arm, the system is designed according to the concept of distributed control. Each of the three sections of the arm contains circuit boards that implement a central processing unit, brake drive, motor drive, motor control, input/output control, analog-signal-acquisition circuit, dual position (joint-angle) monitoring circuit, analog torque-control loop, and power supply (see figure). The circuit boards and cables are designed with wires and shields arranged in multiple layers according to criteria of electromagnetic compatibility.

Excluding its edge connectors, each circuit board measures 4.95 by 4.72 in. (12.57 by 11.99 cm). It includes two printed-circuit cards held on the opposite faces of an aluminum heat-sink plate. Each printed-circuit card contains eight conductor layers, interconnected by plated through holes. Integrated circuits in leadless chip carriers are bonded to pads on the outer surfaces of the cards. To minimize stresses at solder joints, the circuit cards are made of materials, the coefficients of thermal expansion of which match those of the components mounted on the cards. The shoulder section holds 9 circuit boards; the upper section, 12; and the lower section, 11.

The central processing unit (CPU) in each section is rated at 3.2 million instructions per second (MIPS). Each CPU senses positions of joints through inductive encoders that provide the 22 bits of accuracy required for movements precise to 0.001 in. (0.025 mm). Such other parameters as motor currents and torques are sensed through 32 analog input channels. Each CPU controls two or three pulse-width-modulated brushless dc motors. Brake circuits release brakes on command, then reduce power to the level required to hold the brakes off.

This work was done by William Kast of Martin Marietta Corp. for **Goddard Space Flight Center**. *For further information,* ***write in 106*** *on the TSP Request Card. GSC-13456.*



Three Sections of Robot Arm contain circuit modules in the form of standardized circuit boards. Each module contains two printed-circuit cards, one on each face.

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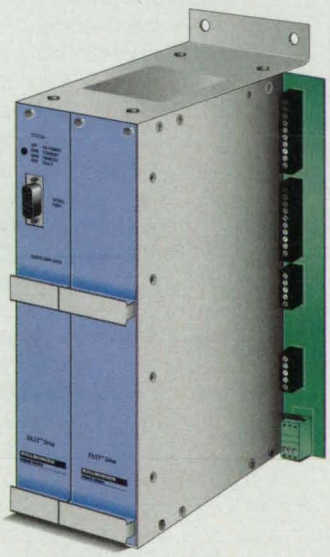
FAST Drive is the new fully digital servoamplifier with technology so sophisticated it seems simple. The Kollmorgen Motion Technologies Group FAST Drive is flexible and adapts to numerous configurations where dedicated hardware was previously required. It controls a broad range of motors including brushless and brush type, linear, printed disc, and AC induction. The "Auto-Config" input automatically adjusts to motor type, pole count, feedback type and motor phasing. Advanced features are user configurable through the RS-232 serial port.



Does all this flexibility require compromise? No—FAST Drive will deliver unparalleled performance due to its extensive tuning capability and advanced communication methods. And for most applications FAST Drive costs about the same as dedicated hardware that would deliver only a fraction of the capabilities. FAST Drive is a powerful, flexible, simple to operate, high value solution. One more way Kollmorgen keeps pushing the edge of the envelope in motion control technology.

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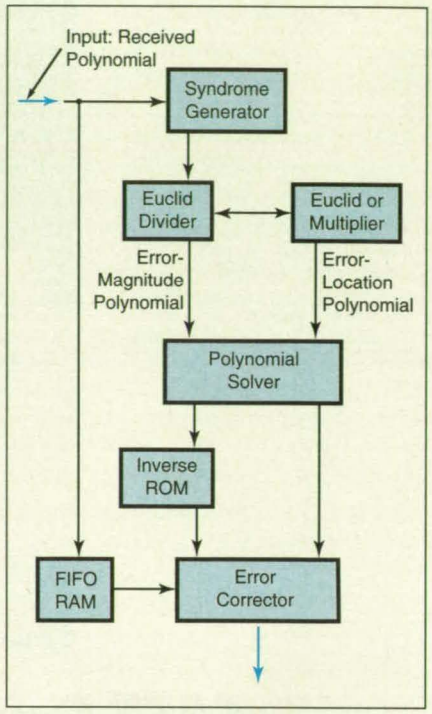
Real-Time Reed–Solomon Decoder

This decoder can correct 16 symbol errors per 255-symbol code block at 80 Mbits/s.

Goddard Space Flight Center, Greenbelt, Maryland

A generic Reed–Solomon decoder fast enough to correct errors in real time in practical applications is designed to be implemented in fewer and smaller very-large-scale integrated (VLSI) circuit chips than are needed to implement older, non-real-time Reed–Solomon decoders. When the generic design is applied to the specific case of a standard Reed-Solomon code of $n = 255$ symbols ($k = 223$ information symbols + $2t = 32$ parity or check symbols) per code word, the result is a decoder that can correct as many as 16 errors per code word at a data rate of 80 MHz.

The decoder is configured to operate in a "pipelined" manner, in which each of four successive code words is at a different stage of processing. Of course this implies that there is a delay as each code word propagates along the pipeline, but once the pipeline is filled, the overall effect of processing is to decode the code words as fast as they are received. The latency (the processing delay) is four code-word periods.



The **Real-Time Reed–Solomon Encoder** operates at high speed in a "pipeline" fashion. It can be implemented in dense, compact VLSI circuitry.

The figure illustrates the major functional blocks of the decoder. Each received code word, representing a polynomial of order $n - 1$, is coupled into the syndrome generator, which calculates the $2t$ syndromes of the received polynomial. The syndromes are the coefficients of the syndrome polynomial, which is a measure of the differences between the received code word (which could contain errors) and the errorless transmitted code word.

The syndromes computed by the syndrome generator are sent to the Euclid divider, which computes an error-magnitude polynomial. One of the quotients computed by the Euclid divider is used by the Euclid multiplier in computing an error-location polynomial. The error-magnitude and error-location polynomials are sent to the polynomial solver, which calculates the first derivative and the location

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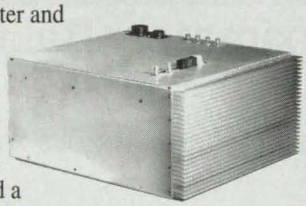

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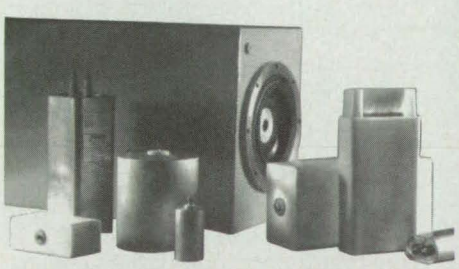

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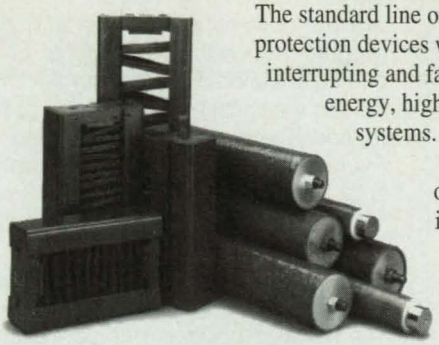
Maxwell's resistors and fuses - for high voltage, high current, and high energy



The standard line of Maxwell high voltage fuses consists of protection devices which act as rapid and reliable circuit-interrupting and fault limiting components to protect high energy, high voltage circuits in industrial electrical systems.

Maxwell high energy resistors are often used in pulse discharge circuits for impedance matching or as a protective device, such as controlling the current in a capacitor bank. They are physically robust, thermally stable and chemically inert, making them ideal for a wide variety of industrial uses.

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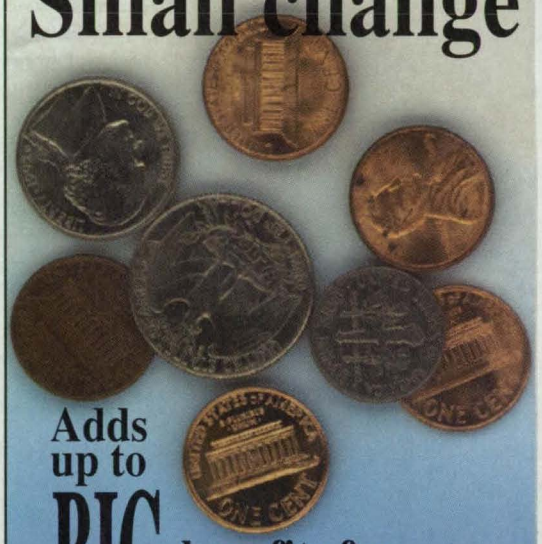
Small change



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of the zeros of the error-location polynomial. The polynomial solver is coupled to the inverse read-only memory (ROM) and to the error corrector. The inverse ROM is programmed with the elements of the particular Galois field (a finite field with modulo arithmetic) over which the code is defined. The inverse ROM is used to find the inverse of the first derivative of the error-location polynomial.

The received polynomial is also coupled into a first-in/first-out random-access memory (FIFO RAM), which is large enough to hold four such polynomials. The received polynomial is passed from the FIFO RAM to the error corrector, wherein the received polynomial is corrected by the magnitude and location information contained in the error-magnitude polynomial, the error-location polynomial, and the inverse of the first derivative of the location polynomial. The correction process involves first multiplying the inverse of the first derivative of the error-location polynomial by the magnitude polynomial, then taking the exclusive-OR of the product with the received polynomial.

The corrected polynomial is then sent to external circuitry for decoding. If the number of erroneous symbols in a code word exceeds t, then the errors are uncorrectable; in such a case, the information symbols are passed on unchanged, along with a status word that indicates the number of errors and the fact that they are uncorrectable.

One of the outstanding aspects of the decoder design is that the Euclid multiplier and divider modules contain Galois-field multipliers configured as combinational-logic cells. These multipliers can operate at speeds greater than those of older multipliers, in part because no clock pulses are needed to toggle data through the multiplier circuitry. The cellular configuration is highly regular and requires very little interconnection area, making it ideal for implementation in extraordinarily dense (and therefore compact) VLSI circuitry.

A flight electronics single chip version of this technology is being implemented and will be available.

This work was done by Gary K. Maki, Kelly B. Cameron, and Patrick A. Owsley of Idaho Research Foundation, Inc., for **Goddard Space Flight Center**. *For further information,* ***write in 100*** *on the TSP Request Card. GSC-13136.*

Designing an Approximately Balanced LQG Compensator

A low-order controller and estimator would control a flexible structure efficiently.

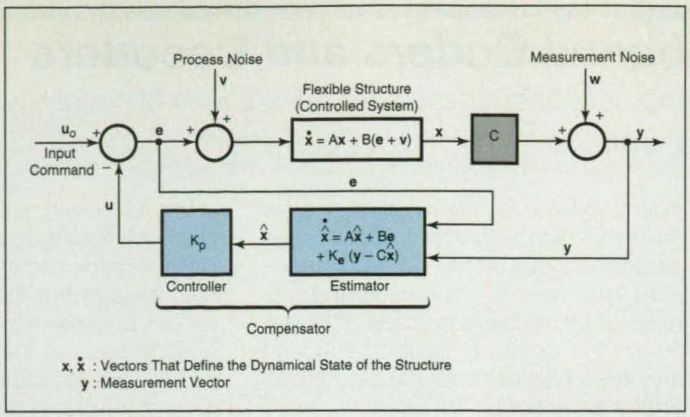
NASA's Jet Propulsion Laboratory, Pasadena, California

A method of designing an approximately balanced (as defined in subsequent paragraphs), low-order linear-quadratic-Gaussian (LQG) compensator for use in feedback control (typically, to suppress vibrations) of a flexible structure has been devised. As used here, "low-order" refers to the order of the mathematical model of the compensator, which one seeks to make lower than the order of the model of the structure to be controlled. The full-order model of a typical structure is too large for use in designing a compensator; a low-order model that can exert control that is less precise but nevertheless acceptable according to some quantitative criterion is therefore sought for the sake of practicality and efficiency.

A lengthy preliminary discussion to define terms and establish the mathematical background is prerequisite to a description of the method. Please refer to the figure for definitions of the relationships among the various components of the overall system and among the design parameters and dynamic variables. The matrices A, B, and C are said to constitute a state-space triple of the flexible structure. The structure is postulated to be controllable and observable, with dynamics characterized by $N/2$ (where N is even) distinct complex-conjugate pairs of poles in the complex-frequency plane, and the real parts of the poles are small. Some aspects of the controllability and observability of the structure are represented by matrices known as the controllability grammian (W_c) and the observability grammian (W_o), which are positive definite and satisfy the Lyapunov equations

$$AW_c + W_cA^T + BB^T = 0,$$
$$A^TW_o + W_oA + CC^T = 0$$

The mathematical model of the structure is said to be open-loop balanced if its controllability and observability grammians are diagonal and equal:



The Compensator Is Part of the Feedback Control Loop used to control a structure; e.g., to aim and to suppress vibrations in a large antenna.

$$W_c = W_o = \Gamma^2, \Gamma$$
$$= \text{diag}(\gamma_1, \ldots \gamma_N),\ i = 1, \ldots, N$$

where $\gamma_i > 0$ is the ith Hankel singular value. (Hankel singular values are singular values of the Hankel matrix that represents the dynamics of the structure.)

The noises **v** and **w** are taken to be uncorrelated, where **v** is the process noise with intensity V, and **w** is measurement noise with intensity W:

$$V = E(\mathbf{v}\mathbf{v}^T),\ W = E(\mathbf{w}\mathbf{w}^T),$$
$$E(\mathbf{v}\mathbf{w}^T) = 0,\ E(\mathbf{v}) = 0,\ \text{and}\ E(\mathbf{w}) = 0$$

where E( ) is an expectation operator. W can be set equal to the identity matrix (I) without loss of generality. The design task is to determine the controller gain (K_p) and estimator gain (K_e) such that the performance index J as given by

$$J^2 = E\int_0^\infty (\mathbf{x}^T Q\mathbf{x} + \mathbf{u}^T\mathbf{u})dt$$

is minimal, where Q is a positive semidefinite state weight matrix.

The minimum of $J\mathbf{x}$ is obtained for the feedback $\mathbf{u} = -K_p\hat{\mathbf{x}}$, where $\hat{\mathbf{x}}$ is the estimator state and the gain matrix

$$K_p = B^T S$$

is obtained from the solution S of the controller Riccati equation

$$A^T S + SA - SBB^T S + Q = 0$$

The optimal estimator gain is given by

$$K_e = PC^T$$

where P is the solution of the estimator Riccati equation

$$AP + PA^T - PC^T CP + V = 0$$

An LOQ compensator is balanced if the solutions of the above Riccati equations are equal and diagonal: $S = P = M = \text{diag}(\mu_i)$, $i = 1,\ldots, n$. This completes the background discussion and definition of terms.

An LQG compensator as described above is an optimal one in the sense of minimization of the performance index, but the performance can be significantly modified through variations of weight Q and variance V. Although V is predetermined by the process noise **v**, it is modified in a search for a more robust solution. Specifically, damping of oscillations (in addition to tracking control as in aiming an antenna) can be obtained by choosing a weight large enough that the resonance peaks of the closed-loop transfer function are flattened, but small enough so that the tracking properties are not degraded. The determination of the weight and covariance is a substantial task, which is addressed by the method described below. The method also provides for reduction of the order of the compensator in such a way as to maintain stability and performance like those of the full-order compensator. The solution to this problem is found through the approximate balancing of controller and estimator Riccati equations.

The method involves five steps, which can be summarized as follows:

1. Obtain the open-loop balanced state-space representation of the structure.
2. Choose matrices Q and V to obtain the required performance (determine either through placement of poles, through observation of resonant peaks of the overall closed-loop system, or through the time-domain performance; e.g., step or impulse responses).
3. Obtain the LQG balanced solution, M of the controller and estimator Riccati equations, along with controller and estimator gains.
4. Form the pole-mobility matrix Σ from

$$\Sigma = \text{diag}(\sigma_1, \sigma_2, \ldots, \sigma_{n-1},$$
$$\sigma_n),\ \sigma_i = \gamma_i^2\mu_i,\ \text{and}\ \Sigma = \Gamma^2 M$$

If some diagonal entries of Σ are much smaller than the remaining ones, truncate the estimator states related to these entries.

5. Verify the stability and performance of the reduced-order compensator.

This work was done by Wodek Gawronski of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 81*** *on the TSP Request Card. NPO-19000.*

Simplified Digital Subband Coders and Decoders

In comparison with older coders and decoders, these offer advantages of simplicity and speed.

Lewis Research Center, Cleveland, Ohio

Simplified digital subband coders and decoders are being developed for use in converting digitized samples of source signals into compressed and encoded forms that maintain the integrity of the source signals (or close approximations of the source signals) while enabling transmission at low data rates. Like older subband coders and decoders, these are based on the concept of dividing the source signal into frequency subbands, within each of which encoding can be performed by a method suited to the characteristics of the signal data in that subband. Examples of such coding methods that can be used in the subbands include coarse quantization in the high-frequency subbands, differential coding, predictive coding, vector quantization, and entropy or statistical coding.

The main disadvantage of older subband coders is the need to perform finite-impulse-response filtering, which necessitates many arithmetic operations and relatively complicated circuitry (multipliers and accumulators). Typically, older subband decoders cannot operate rapidly enough to process data at rates as high as those of video signals. In contrast, the only arithmetic operations required by the basic principle of operation of the simplified digitized subband encoders and decoders are additions and subtractions. As a result, these encoders are not only simpler (and therefore less expensive) but are also expected to operate rapidly enough to process video signals.

The main components of a simplified digital subband coder and decoder are adders, subtractors, buffers, shift registers, counters, memories, timing circuits, and address-control logic circuits. In one version of a basic encoder of this type, which is equivalent to a Walsh–Hadamard transform (see figure), a serial input stream of is read into a serial-to-parallel register that holds two consecutive samples. The two samples are latched and passed on to an adder and subtractor for processing; then two new samples are read into the serial-to-parallel register.

The adder and subtractor perform the frequency filtering in effect: Inasmuch as the sum of the two samples is equivalent to an average or smoothed value, the adder can be regarded as a low-pass filter. Similarly, because the difference between the two samples is a measure of the variability of the signal, the subtractor can be regarded as a high-pass filter. Because of the arithmetic processing, the outputs of the adder and subtractor have twice the range of the input, necessitating an additional bit in the result. This bit must be accommodated for perfect reconstruction of the input data in the decoder, but it can be dropped by a shift right, essentially dividing by 2, if less-than-perfect reconstruction is acceptable.

At the output terminals of the adder and subtractor, the signal has thus been split into high- and low-frequency subbands. Further splits can be obtained by cascading this basic encoding structure into a tree structure. Optionally, compression coding may be applied to the subbands.

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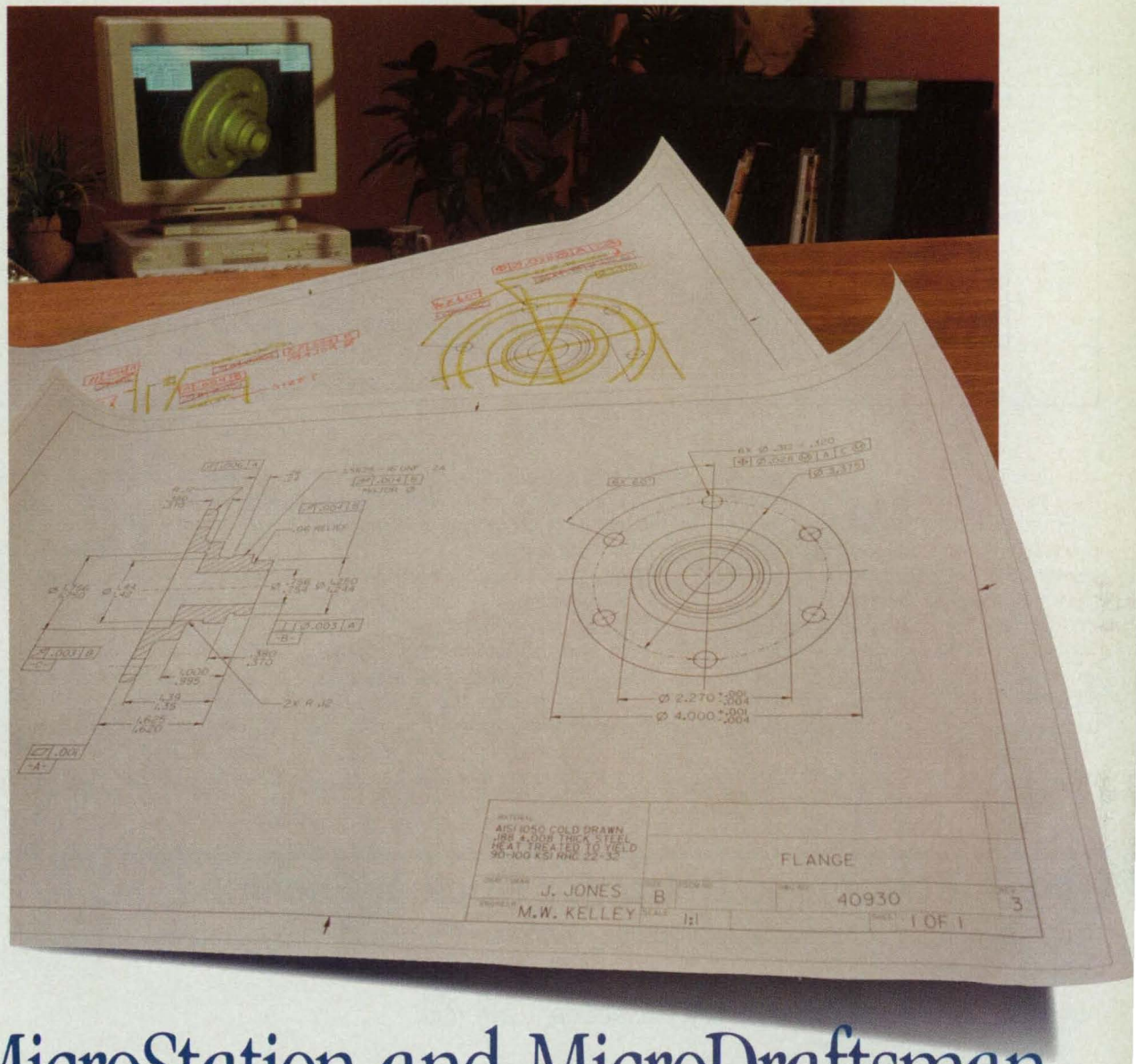

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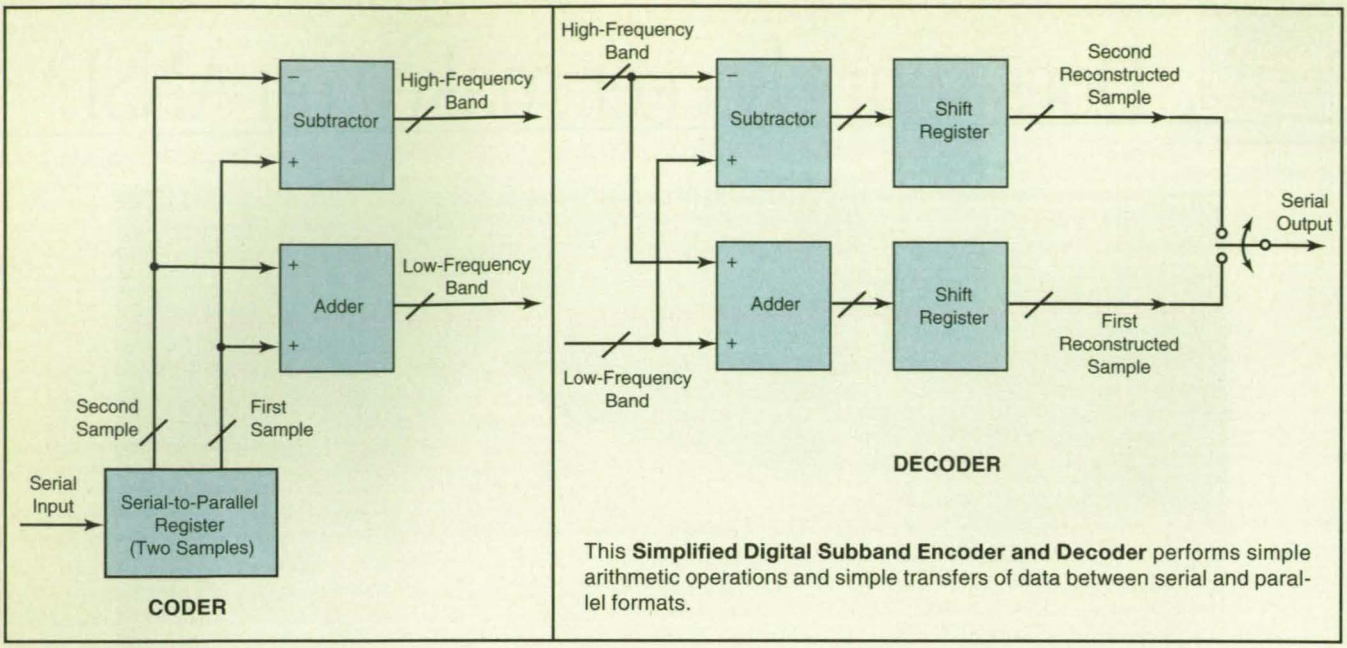


This **Simplified Digital Subband Encoder and Decoder** performs simple arithmetic operations and simple transfers of data between serial and parallel formats.

In the decoder, the incoming bit streams in the subbands are latched into registers. The low-band and high-band code samples are added to reconstruct the first original data sample in a pair, then subtracted to reconstruct the second original data sample in the pair. Then the next pair of code samples is received, and the process is repeated to reconstruct the sequential original data samples. The addition and subtraction can be accomplished simultaneously by use of a separate adder or subtractor as shown in the figure, or sequentially by use of one adder and changing the sign of the high-frequency-band code sample to perform the subtraction.

The most useful concatenation of basic simplified digital subband coder and decoder circuits is expected to be in the form of a two-dimensional, separable filter bank for processing image data. In this and other uses, the circuitry can be implemented in a variety of serial- and parallel-processing configurations and constructed by any of a variety of discrete-component or integrated-circuit technologies.

This work was done by Daniel R. Glover of **Lewis Research Center**. *For further information,* ***write in 13*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center, [see page 20]. Refer to LEW-15310.

Tele/Autonomous Robot for Nuclear Facilities

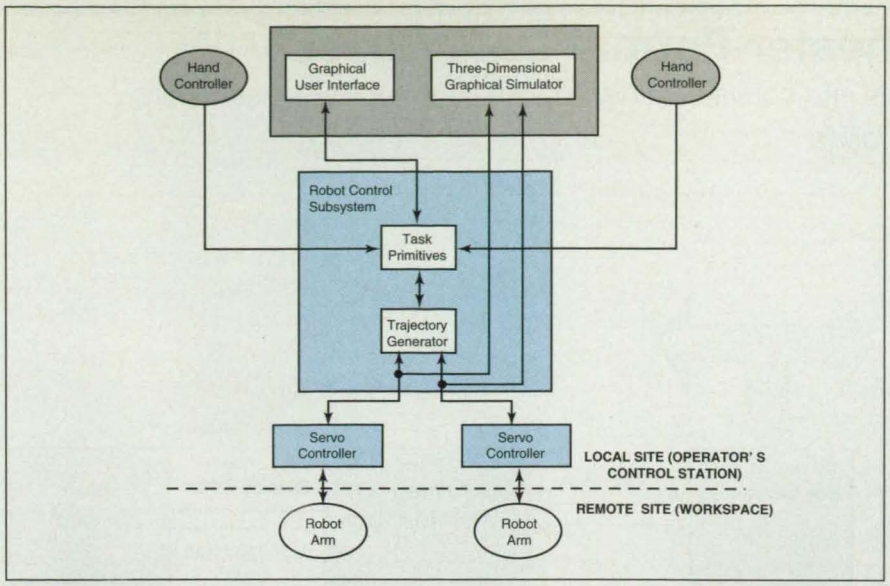
Technology from outer-space telerobotics enables safer operation in hazardous terrestrial environments.

NASA's Jet Propulsion Laboratory, Pasadena, California

A fail-safe tele/autonomous robotic system is described which makes it unnecessary for human technicians to enter nuclear-fuel-reprocessing facilities and other high-radiation or otherwise hazardous industrial environments. The system exploits technology from outer-space telerobotics to enable human operators to supervise remote robots in performing terrestrial repair, maintenance, and processing tasks. Features of the outer-space telerobotic system that are relevant to this development include the separation of computing facilities into local (operator's control station) and remote (workspace) sites, teleoperation, autonomous generation of motion in robot-joint or Cartesian coordinates, (that is, remote control), voice interaction between the operator and the robots, shared control between the autonomously generated motions and operator-controlled teleoperation, and generation of coordinated dual-arm trajectories. The outer-space telerobotic system has been used to carry out such realistic experiments as exchanging equipment modules, turning bolts, cleaning surfaces, and grappling turning objects by use of a mixture of autonomous actions and teleoperation with either a single arm or two cooperating arms.

The approach taken in developing the tele/autonomous robotic system is to provide a robust, sophisticated robotic control subsystem and a well-integrated user interface. The control subsystem is capable of fully autonomous operation for performing precise and repetitive process steps, teleoperation for unusual maintenance tasks, and shared control for processes that are too complex for either fully autonomous operation or pure teleoperation. The prototype tele/autonomous robotic system (see figure) includes a graphical interface for use by an operator in executing tasks robotically, hand controllers for teleoperation, a 3-dimensional graphical simulator, and robot-control software to drive both the graphical simulation and dual 6-degree-of-freedom robots to perform tasks using autonomous, teleoperated, and shared control modes.

The system is divided between the local site, where the operator sits, and the remote site, where the manipulators



The **Tele/Autonomous Robotic System** is capable of fully autonomous operation, teleoperation (direct remote control by the operator), or shared control (a combination of autonomous operation and teleoperation).

work. The components at the remote site are minimized because of the high radiation there. For most commercial robots, this means that only the robot arms are placed at the remote site, with their servo controllers placed outside the high-radiation workspace. For radiation hardness and high reliability, the robot arms should be connected to the control subsystem via optical fibers.

The system is designed as a hierarchy of levels:

- **Operator Level**: The top level of the hierarchy includes the user interface for the operator to exert overall control over robotic tasks. The operator can send a command to the system to execute the task autonomously, operate the hand controller to control the robot in teleoperation, or choose a combination of both in the form of traded and shared control mode
- **Task Level**: This level accepts task commands from the operator and provides task primitives to perform the tasks. (A task primitive is a computer program that converts the operator's task commands into the required trajectory commands plus commands that implement the appropriate control laws. Experiments have shown that very few parameterized task primitives are needed to accomplish most robotic servicing tasks.)
- **Trajectory Level**: This level includes a trajectory generator that computes the manipulator setpoints required to execute the motions requested by the task primitives.
- **Servo Level**: This lowest level provides servo control of the manipulator-joint positions. It implements a proportional/integral/derivative control loop and normally runs at a rate between 200 and 1,000 Hz.

This work was done by Paul G. Backes of Caltech and Kam S. Tso of SoHaR, Inc., for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 19*** *on the TSP Request Card. NPO-18924.*

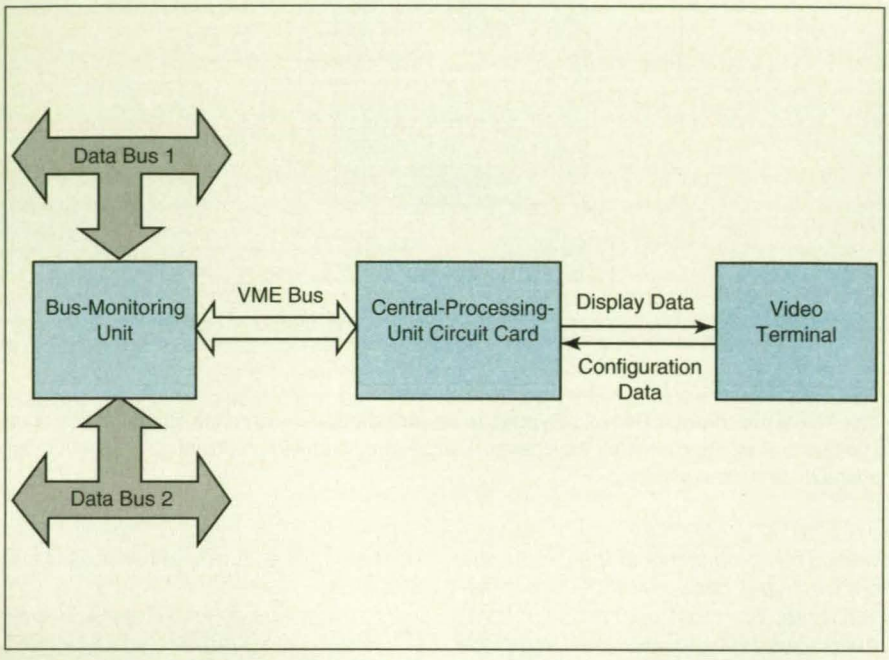
Unit Monitors Manchester-Format Data Buses

A circuit card converts data signals into convenient hexadecimal form for troubleshooting.

John F. Kennedy Space Center, Florida

A bus-monitoring unit converts data signals from the Manchester II format used on the data bus into hexadecimal format, which is more convenient for troubleshooting. The monitoring circuit causes the hexadecimal words to be displayed on a video terminal, where a test engineer can compare them with hexadecimal records for troubleshooting. The circuit can monitor one bus or two buses simultaneously.

The use of the bus-monitoring unit measurements replaces a tedious, labor-intensive process in which the test engineer connected an oscilloscope to the bus, then read the 16-bit Manchester II pattern from the screen. Manchester code is difficult to read because it contains mid-clock-period, signal-level transitions that represent 0's and 1's. For example, a 1 is represented by a high level followed by a low, or a 0 is represented by a low level followed by a high within one clock period. The test engineer had to read 16 such bits for each word and manually record each to convert the Manchester signal to binary. The engineer then had to convert from binary to hexadecimal to obtain data in the proper form. As a result, only a handful of words were available. With the bus-monitoring unit, data for troubleshooting are plentiful.



The **Bus-Monitoring Unit**, with the help of an external central-processing-unit circuit card, monitors one or two data buses and converts Manchester-II-format signals on the buses into hexadecimal format for display on the video terminal.

The unit can monitor any biphase bus that carries data words between 2 and 28 bits long. The unit is configurable via software, with the use of a video terminal. The test engineer can configure it to monitor one bus or two, to detect or not to detect single bit errors, to select parity, and, optionally, to capture all data following a selectable trigger word.

The unit can capture as many as 1,024 words (i.e., each 16-bits long or less) and store them in first-in, first-out integrated-circuit memories. For data words greater than 16-bits long, the unit can capture as many as 512 words. Two identical monitoring circuits — one for each of the two buses — are mounted on a single VMEbus circuit card, along with memory, and interface-logic circuits. An external commercial VMEbus central-processing-unit (CPU) circuit card coordinates the operation of the unit. It contains the necessary firmware and processes the data for display on the video terminal.

This work was done by Jose J. Amador of **Kennedy Space Center**. *For further information,* ***write in 14*** *on the TSP Request Card. KSC-11617.*

Approximating Effect of Spherical Radiation Pattern

Adjacent transmitting antennas would be excited sequentially with replicas of the same signal.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed time-division multiple-access (TDMA) multichannels radio communication system (see figure) would implement a scheme of temporal and spatial multiplexing of signals to approximate the effect of a spherical antenna radiation pattern. The scheme relies on repetitively transmitting time-compressed replicas of each signal epoch from a multiplicity of switched antennas having spatially nonoverlapping patterns. The same antennas would be used for reception during the receiving time slots by examining all received signals simultaneously and either (1) selecting the strongest of the received signals or (2) employing any one of a number of classical diversity combining techniques for enhanced signal-to-noise ratio.

In the proposed scheme, the transmitting station would be equipped with *n* antennas configured so that the peaks of the radiation patterns of some of them would overlap the nulls of the radiation patterns of others: More specifically, the radiation patterns of the *n* antennas would be designed so that if the radiation patterns were to be measured when the same transmitter signal was applied to one antenna at a time, in sequence, and the power radiated in each direction then averaged over all antennas, the average radiation pattern would be approximately spherically symmetrical.

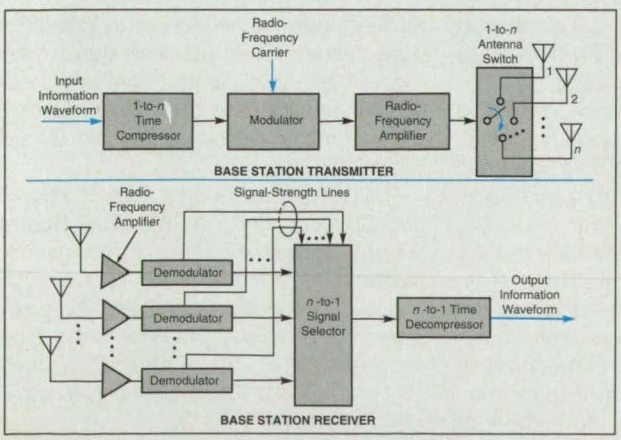
In a base-station transmitting according to this scheme, the input information waveform to be transmitted would first be fed to a time compressor, which would generate *n* replicas of the input waveform speeded up by a factor of *n*. The time-compressed waveform would be used to modulate the carrier signal. An antenna switch synchronized with the time compressor would direct the transmitted power in turn to each antenna, such that each would radiate a signal bearing one of the speeded-up replicas of the input information waveform.

The same base station configured according to this scheme would receive as many as *n* repetitions of the same information, the exact number of repetitions depending on its position relative to the transmitting station. The signal received by each antenna would be demodulated separately to recover a version of the speeded-up information waveform. One of these signals (e.g., the strongest one) could be selected over the others, and the output of the corresponding demodulator could be processed through a time decompressor to recover a version of the information waveform. Alternatively, a diversity-reception demodulated-signal-combining technique could be used.

This work was done by Louis Sickles II of Martin Marietta Corp. for **Johnson Space Center**. *For further information,* ***write in 43*** *on the TSP Request Card.*

Title to this invention, covered by U.S. Patent No. 5,194,873, has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)]. Inquiries concerning license for its commercial development should be addressed to: Office of Patent Counsel; Bldg. 100, Room M7211; P. O. Box 8555; Philadelphia, PA 19101.

Refer to MSC-21965, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Signal To Be Transmitted** would be sped up by a factor of *n* and transmitted in *n* replicas via *n* antennas. During reception, the incoming signal would be processed by use of a maximum-signal-selection or a diversity-reception demodulated-signal-combining technique.

Thermotile Refrigerators

Thermoelectric tiles would provide cooling exactly where needed.

Marshall Space Flight Center, Alabama

"Thermotile" denotes a proposed modular cooling device (see Figure 1) that would include thermally conductive heat-transfer surfaces, a thermoelectric cooling device, a temperature sensor, and logic and control circuits. Thermotiles have been proposed as building blocks for refrigerators. The walls of such a refrigerator would be lined with thermotiles (see Figure 2), which would be supported by lattice structures on or near the surfaces of thermally insulating layers in the walls. Long, thin thermotiles would be mounted under door seals to compensate for heat lost through the seals.

Coolant (probably water) would be delivered to each thermotile, at a known temperature and rate of flow, from a central heat exchanger. Power from a common dc source would be supplied to all the thermotiles. Heat would be transferred to the fluid by conduction from the thermoelectric cooling device on each tile. The electronic circuits in each tile would be connected to a master controller that would provide temperature-control settings, perform tests, and monitor the consumption of power. The controller would, in turn, be connected to a central processing unit through which one or more temperature(s) could be monitored and/or controlled.

The temperature sensor in each thermotile would detect the local temperature, and the logic circuit in the thermotile would compare the local temperature with the temperature setting provided by the central processing unit. Depending on whether the local temperature was below or above the setting, the control circuit in the thermotile would command a proportional decrease or increase, respectively, in the current supplied to the thermoelectric cooling device of the tile. For example, as the local temperature decreased toward the set temperature, the current would be made to decrease until a steady temperature and steady corresponding current were attained. The precise form of the temperature-vs.-current curve would be programmed into the master controller. Thermotiles in a freezer compartment would operate in the same manner as those in a refrigerator, except that larger constant currents would be needed to maintain the lower steady-state temperature.

Unlike in some conventional refrigerators, air would not be the principal cooling medium in a thermotile refrigerator. Therefore, fans used to circulate air within the thermotile refrigerator could be smaller than in conventional refrigerators. When the refrigerator door was opened, and ambient air entered, cooling action would increase only at those tiles that were warmed by the entering air. Slides for food drawers in the refrigerator would be made of thermally conductive material, such as aluminum, and would be thermally connected to the thermotiles. Food in the drawers would therefore be cooled by conduction through the drawers as well as by contact with the cool air circulated by the fan(s). Any increase in heat load would be handled by the nearest thermotiles. Heat released by operation of fan motors and by resistive heating in the distribution of electric power would add somewhat to the heat loads on the thermotiles.

The thermotile approach could be applied to enclosures of various shapes and sizes. The same tiles could be used in small enclosures with thin insulation or in larger enclosures with thick insulation. Thermotiles would eliminate the need for conventional mechanical refrigeration machinery and for the lubricants and the chlorofluorocarbons used as working fluids in such machinery. Elimination of conventional mechanical refrigeration machinery would reduce the number of moving parts and would almost completely eliminate noise and vibration. In the event of failure of a thermotile, the surrounding thermotiles would compensate by increasing their cooling action, and the defective tile could be replaced without any need to replace the remaining tiles. The data capabilities of a thermotile refrigeration system could be used for diagnosis of defects or monitoring local temperatures. Thermotiles could be produced by automated manufacturing techniques. Custom shapes could be molded as needed.

The main problem in the development of thermotile refrigerators is to manufacture thermoelectric materials that exhibit acceptable coefficients of performance. Such materials have been demonstrated, and efforts to develop them further are continuing.

This work was done by Brian V. Park of ILC Space Systems for **Marshall Space Flight Center.** *For further information,* ***write in 46*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28830.

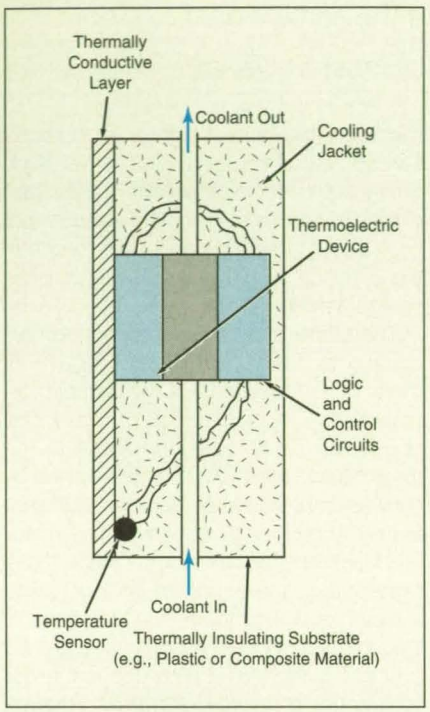


Figure 1. A **Thermotile** would be a modular thermoelectric cooling unit that would incorporate a sensor and electronic circuitry in addition to a thermoelectric device.

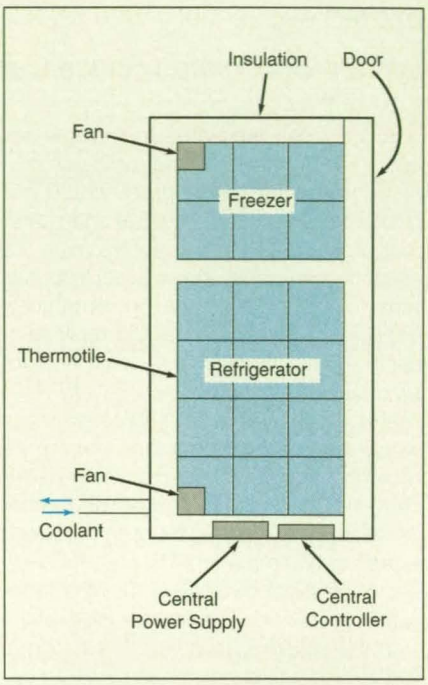


Figure 2. A **Thermotile Refrigerator/Freezer** would be lined with thermotiles clipped into supporting lattices. Small fans would be used to circulate air in the refrigerator and freezer compartments.

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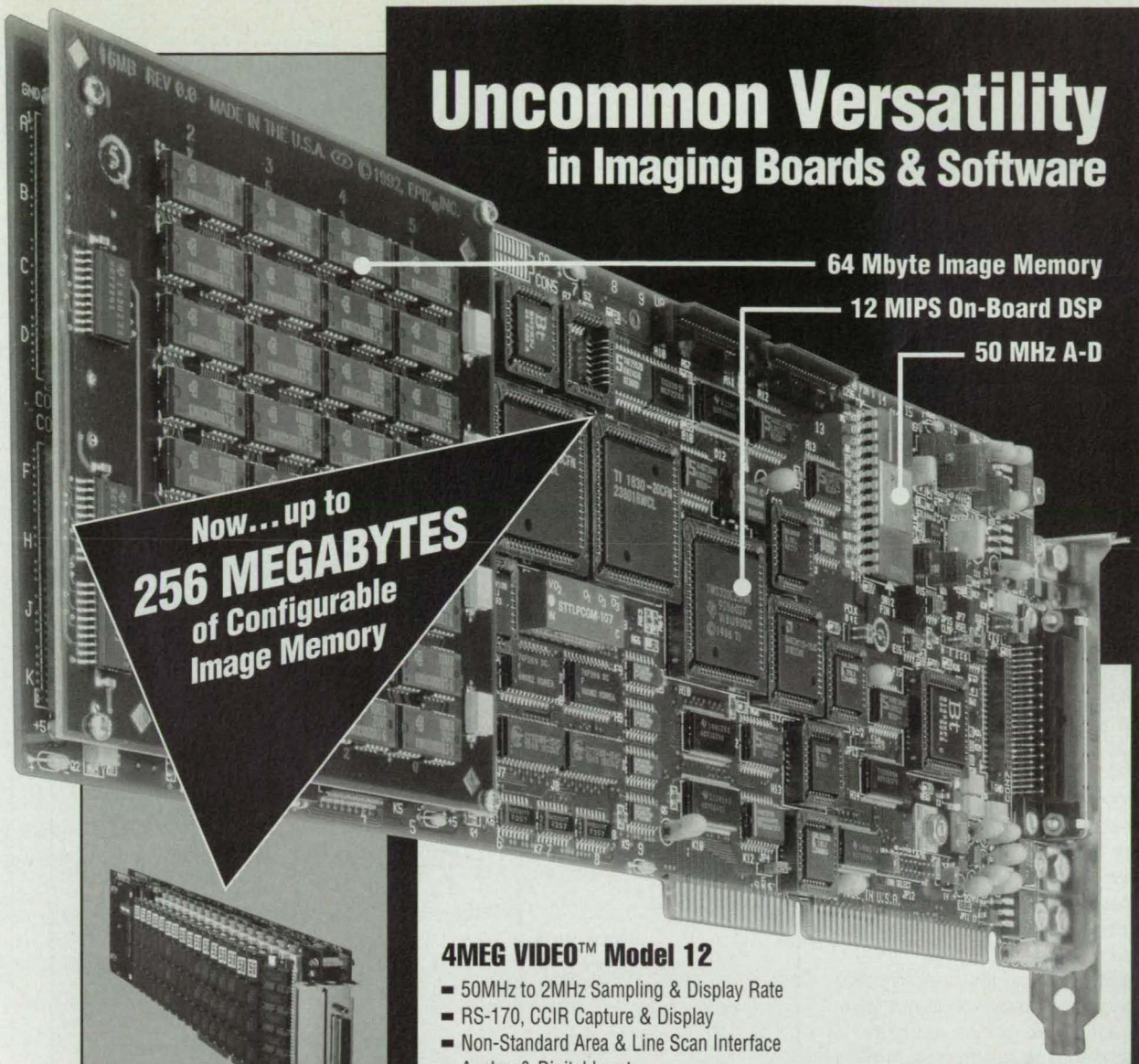

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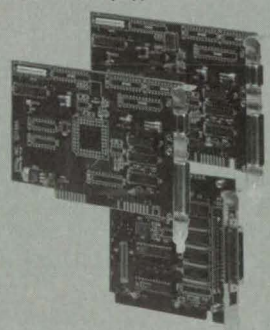

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Imaging Domains in Magnetic Garnets by Use of TSMFM

Resolution is not limited by diffraction as in partly optical techniques.

NASA's Jet Propulsion Laboratory, Pasadena, California

Tunneling-stabilized magnetic-force microscopy (TSMFM) has been demonstrated to yield images of magnetic domains in low-coercivity magnetic garnets with perpendicular anisotropy. The ability to generate images of domain walls and minute vertical Bloch lines should aid the study of vertical-Bloch-line magnetic memory devices that contain garnets. Heretofore, magnetic domains have typically been imaged in some cases by decorating the surfaces of a specimen with ferrofluids and observing the resulting patterns optically. In other cases, domains have been imaged by use of the magneto-optical Faraday effect. These partly optical imaging techniques are limited, by diffraction, to the depiction of features no smaller than approximately the wavelength of light (about 0.5 μm). Resolution finer than this is needed to depict the magnetic features of interest in research on advanced magnetic memory devices.

TSMFM can provide the desired resolution because its resolution is not limited by diffraction. As shown in Figure 1, TSMFM is related to scanning tunneling microscopy (STM), in which electrons tunnel quantum mechanically between a sharp electrically conductive probe tip and the nearby surface of the specimen. (The garnet specimen is coated with gold to make it electrically conductive.) As in STM, a feedback control system with piezoelectric actuators strives to maintain the tunneling current constant, thereby maintaining a constant distance between the probe tip and the surface of the specimen.

Unlike in STM, the probe tip lies at the end of a gold-coated nickel cantilever spring. The nickel spring, being magnetic, flexes in response to the force exerted on it by the fringing magnetic field of the specimen. Therefore, the actuator signal developed by the control system is a measure of the magnetic force and the specimen magnetic field in the vicinity of the probe tip.

The cantilever spring probe used to demonstrate the concept was made by cutting a strip of nickel foil 0.5 μm thick into a sharp triangle. The nickel probe and the garnet specimen were coated with gold about 100 nm thick. The average gap between the nickel tip and the specimen was maintained at about 1 nm, and the average maximum displacement of the tip was about 100 nm.

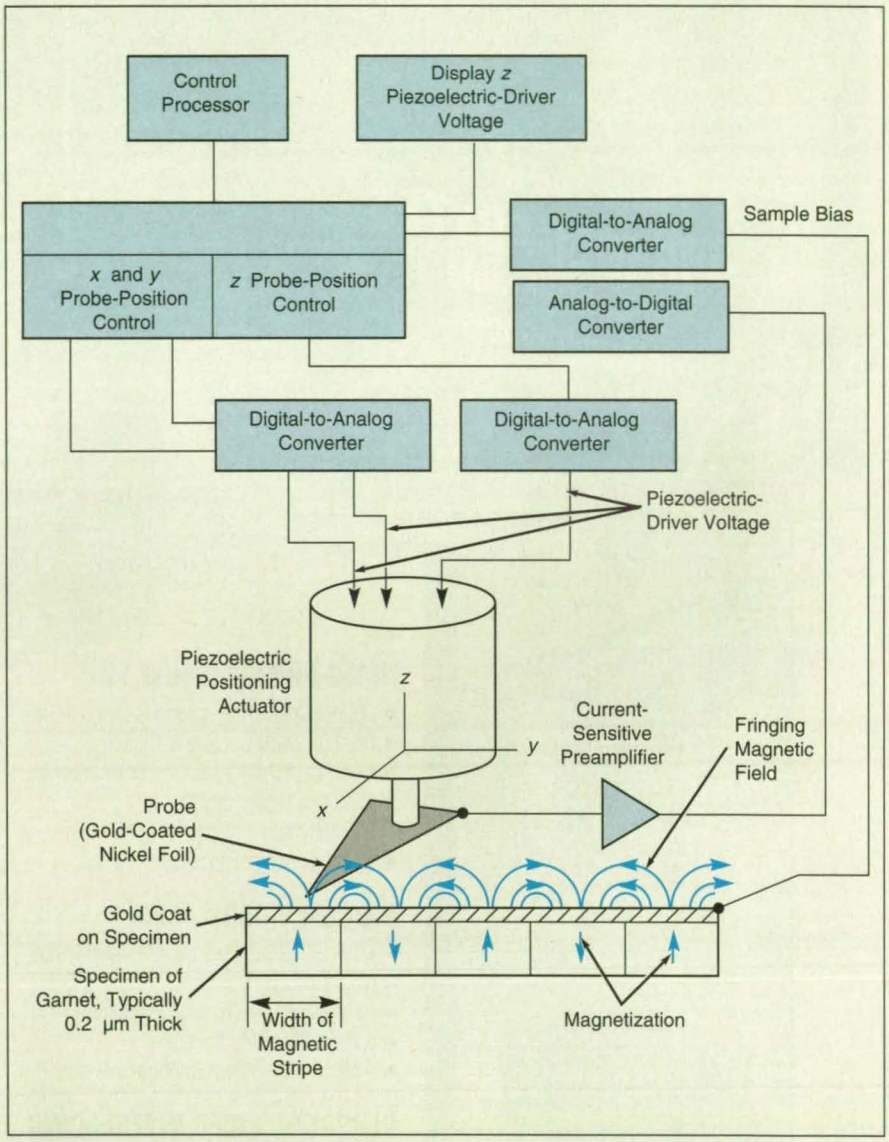

Figure 1. **Tunneling-Stabilized Magnetic-Force Microscopy** (TSMFM) is similar to scanning tunneling microscopy, except that the probe is a cantilever spring of magnetic material (nickel), and what is measured is primarily the force of the magnetic fringing field of the specimen upon the tip. Thus, the TSMFM apparatus generates a map of the fringing magnetic field near the surface of the specimen.

Figure 2 shows a TSMFM image made in the demonstration. It indicates that the spatial period of magnetization (approximately twice the width of a magnetic stripe indicated in Figure 1) is about 4.2 ± 0.42 μm. The periodicity and shapes of the stripes in this image are

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consistent with those observed by use of ferrofluid decoration and the Faraday effect. Furthermore, the spatial period of the stripes is consistent with that of the fringing magnetic field calculated theoretically for garnet. Despite the low coercivity of the garnet, the probe tip does not appear to have disturbed the domain structure of the garnet. Furthermore, the magnetization of the garnet does not appear to have disturbed the tip.

This work was done by Romney R. Katti, Jiin-Chuan Wu, and Henry L. Stadler of Caltech and Paul Rice of the National Institute of Standards and Technology for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 69*** *on the TSP Request Card. NPO-18726.*

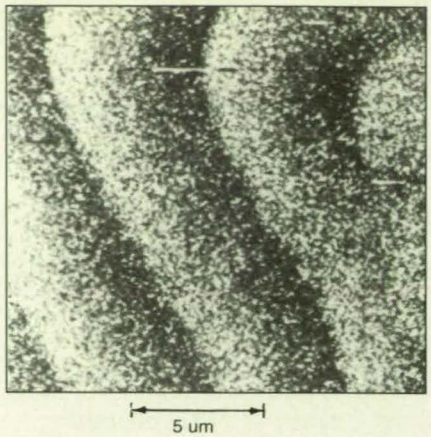


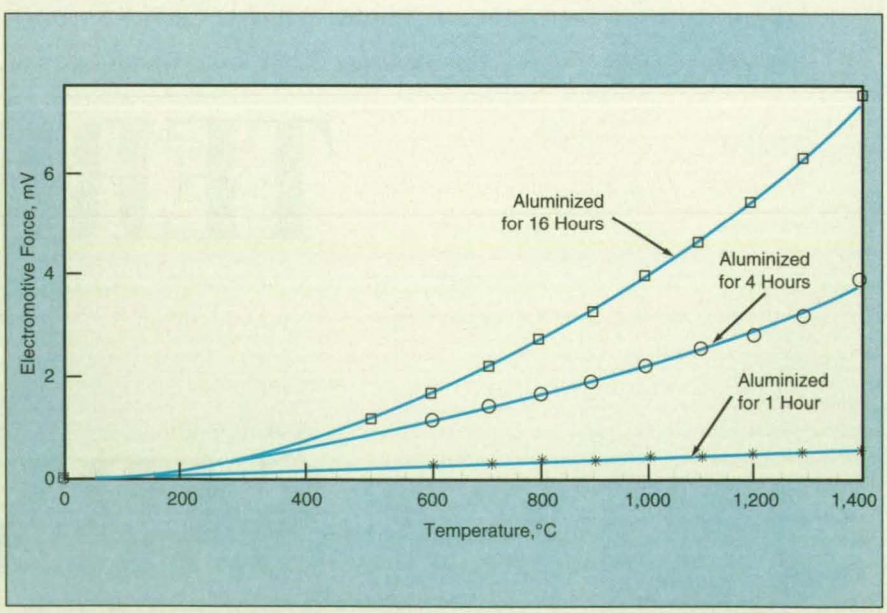
Figure 2. This **TSMFM Image** shows regions of attraction (light) and repulsion (dark) between the probe tip and the specimen. The general appearance and spatial periodicity of this image are consistent with those of images made by other techniques.

High-Temperature, Oxidation-Resistant Thermocouples

Aluminum is substituted for rhodium, which is scarce and expensive.

Lewis Research Center, Cleveland, Ohio

An alternate Pt-type of thermocouple gives reproducible readings in an oxidizing atmosphere or in a vacuum. The two legs of a thermocouple of this type are made of platinum and a platinum/aluminum alloy, respectively. Heretofore, the thermocouples used most commonly at temperatures above 1,000°C have been made with legs of platinum and 87 weight percent platinum/13 weight percent rhodium: these thermocouples are denoted "type R" and they perform well in hot, oxidizing atmospheres. However, rhodium is scarce and expensive at about $4,000/ounce (about 1.4×10^5/kg) (1992 prices). The ability of a thermocouple of platinum and platinum/aluminum to resist hot oxidation derives from a protective scale of aluminum oxide on the surface of the platinum/alu-



The **Electromotive Force Increases With Aluminum Content** in the Pt/Al leg of a Pt/(Pt/Al) thermocouple. Therefore, wires baked longer in an aluminizing bed produce larger voltages.

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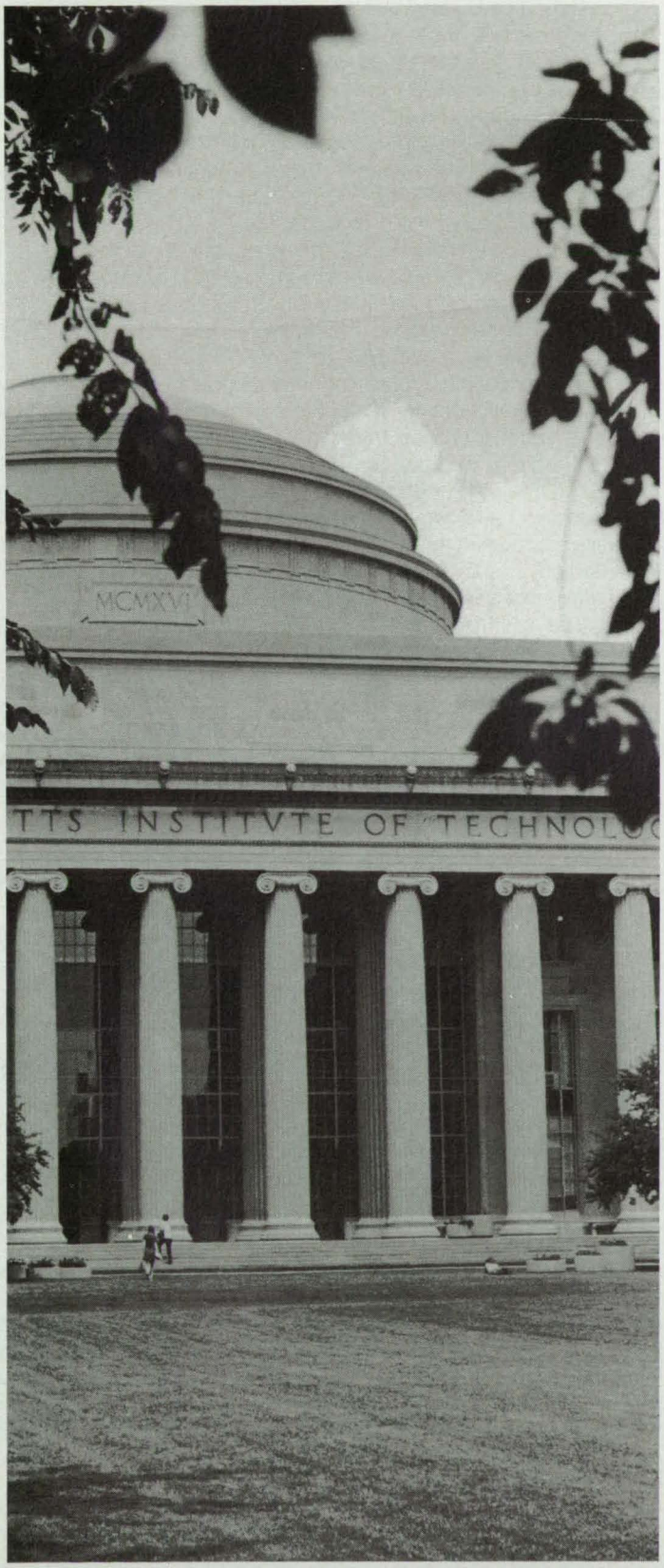

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minum alloy leg. (The platinum leg is inherently resistant to oxidation.)

Platinum/aluminum legs for use in demonstrating the present thermocouple concept were made from platinum wires 0.045 in. (1.1 mm) in diameter. The wires were aluminized by heating them for various times (1, 4, and 16 h) at a temperature of 1,000°C in a bed of aluminum oxide sand containing 2 percent aluminum powder and 2 percent ammonium chloride as an activator. During the heating, the platinum wires became enriched with aluminum to various degrees and depths that depended on the heating times. The Pt/Al wires were spot-welded to Pt wires to form thermocouples.

The electromotive force produced by the thermocouples was found to depend on the heating times. The thermocouple that contained the Pt/Al wire aluminized for 16 h generated 7 mV at 1,400°C. (A thermocouple of type R generates 16 mV at the same temperature.) The thermocouple that contained the Pt/Al wire aluminized for 4 h produced only 4 mV, but in practice it would be preferable to the thermocouple containing the 16-h wire because it would be more ductile. The thermocouple that contained the wire aluminized for 1 h produced only 0.5 mV — too low to be practical. The measured electromotive forces of these three thermocouples are shown in the figure.

Thermocouples containing platinum/ aluminum legs can be used instead of thermocouples of type R in furnaces, heat engines, and chemical reactors. They are especially suited to high-velocity oxidizing environments. They could be constructed as thin-film sensors on turbine blades and vanes, where preoxidation could provide the insulating film needed between the thermocouple legs. Because the aluminum content is slowly depleted by oxidation, long-term use is recommended only where the maximum temperature is 1,200°C or less.

This work was done by James L. Smialek and Michael A. Gedwill of **Lewis Research Center**. *For further information,* ***write in 8*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,275,670). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 20]. Refer to LEW-15515.

Gas-Chromatographic Determination of Water in Freon PCA

Concentrations in the range of parts per million are measured.

Marshall Space Flight Center, Alabama

A gas-chromatographic apparatus measures small concentrations of water in specimens of Freon PCA (or equivalent). The apparatus consists mainly of a gas chromatograph equipped with a porous-packed column and a thermal-conductivity detector. The injection port of the gas chromatograph is surrounded by a plastic bag purged with high-purity helium to prevent condensation of moisture on specimen containers and on a syringe that is used to inject specimens. The apparatus was devised to satisfy a need to inspect commercially obtained lots of Freon PCA (or equivalent), the water contents of which were required to be no more than 10 parts per million.

In comparison with two techniques previously used to determine the water contents of Freon PCA specimens — Fourier-

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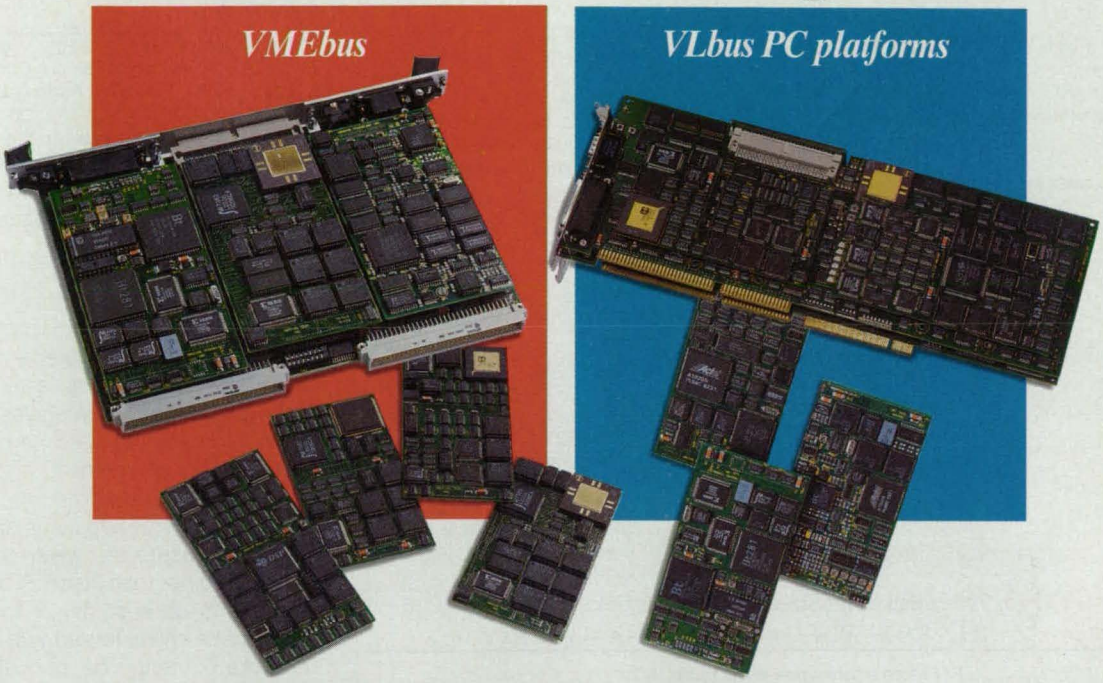

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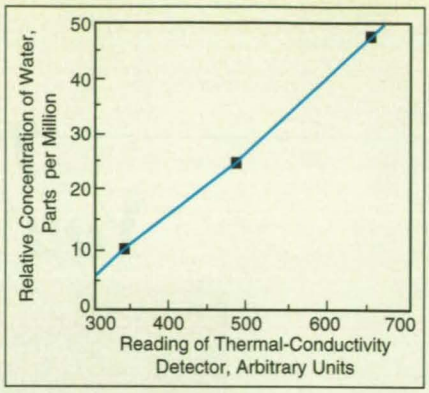

This **Calibration Curve** for the chromatographic apparatus is a polynomial fit to readings on specimens that contained known concentrations of water as measured by Karl Fischer titration.

transform infrared spectroscopy and Karl Fischer titration (see figure) — testing by use of this apparatus is faster and provides greater protection against accidental contamination of specimens by water in the testing environment. Also, this apparatus can be automated for unattended operation. This apparatus can also be used to measure the water contents of materials, other than Freon PCA, that are required to be kept dry or that are required to be characterized with respect to moisture content. The innovation could be extended to the development of a purgeable sampling accessory for gas chromatographs; current sampling accessories are not equipped to contain an inert or dry environment.

This work was done by Donald M. Melton of Martin Marietta for **Marshall Space Flight Center**. *For further information,* ***write in 88*** *on the TSP Request Card. MFS-28905.*

Preventing Supercooling Of Gallium

Heterogeneous nucleation ensures reproducibility of crystallization when gallium is cooled below 29 °C.

Lyndon B. Johnson Space Center, Houston, Texas

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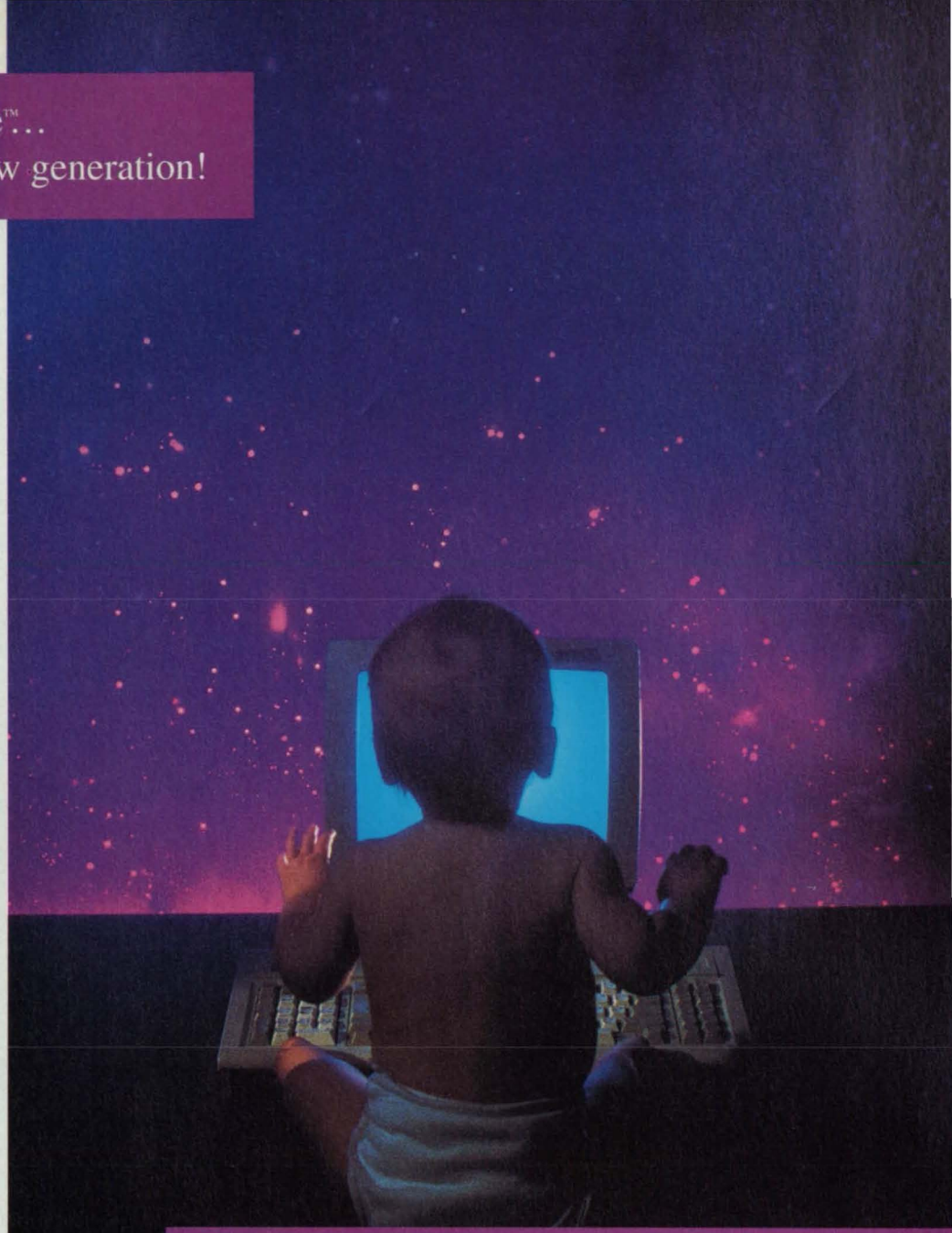

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Lightweight units detect concentrations as low as 10 parts per billion.

John F. Kennedy Space Center, Florida

A prototype active sampling unit capable of detecting hydrazine (HZ) and monomethyl hydrazine (MMH) vapors at levels as low as 10 ppb in air has been developed. Like hydrazine-vapor-sampling devices described previously in *NASA Tech Briefs* ["Dosimeter Badge Detects Hydrazines" (KSC-11556), Vol. 17, No. 12 (December 1993), p. 56], this unit is based on the use of paper strips coated with vanillin-based chemicals, which react with HZ and MMH, turning yellow to a degree proportional to the concentration of HZ or MMH.

The paper strips used in the sampling unit are coated with vanillin (4-hydroxy-3-methoxybenzaldehyde). The coated strip is incorporated into a badge sandwiched between two cards. Each badge is sealed in a packet to ensure the integrity of the hydrazine-sensitive coating until the time of use.

The prototype sampling unit (see Figure 1) includes a detachable badge holder and a pump which draws air through the badge holder at a selectable rate of 1 or 2 L/min. The coated strip in each badge is designed to align with the air passage in the badge holder. Two types of badge holders have been constructed: one has an open-face design for general monitoring of air in open spaces, while the other has a closed-face design with a viewing win-

melting temperature of 29 to 30°C. In the original intended application, gallium would be used as a heat-storage material in gloves of space suits. A potential terrestrial application might lie in the preparation of freezing-temperature reference samples for laboratories. The principle of heterogeneous nucleation might also be exploited similarly in heat pipes filled with sodium.

Pure liquid gallium does not crystallize reproducibly when it is cooled below 29°C; often, the liquid metal can be cooled below 0°C without inducing crystallization. However, the deliberate introduction of a small amount of another metal or metals creates sites for heterogeneous nucleation — that is, nongallium sites where gallium crystals can begin to grow.

In preparation for experiments to test the heterogeneous-nucleation concept, several candidate metals for addition to gallium were selected on the basis of crystal type, interfacial wetting with liquid gallium, and solubility in liquid gallium. In the experiments, these metals were mixed with liquid gallium at a temperature of 300°C for 15 min and then mixed for 15 min at 150°C by use of a laboratory homogenizer. Samples were then tested for reproducible crystallization by cycling between 20°C and 45°C. The best results (100-percent-reproducible crystallization of liquid gallium) were obtained by use of copper, silver, and copper/silver mixtures at 5 to 10 percent by weight in liquid gallium. Promising results were also obtained with other metals, including germanium, neodymium, and lead. The evaluation of various metal salts and oxides was also carried out. None of the compounds tested yielded reproducible gallium crystallization.

This work was done by Arthur A. Massucco, Hans M. Wenghoefer, and Ronnie Wilkins of Arthur D. Little, Inc., for **Johnson Space Center**. *No further documentation is available. MSC-22031.*

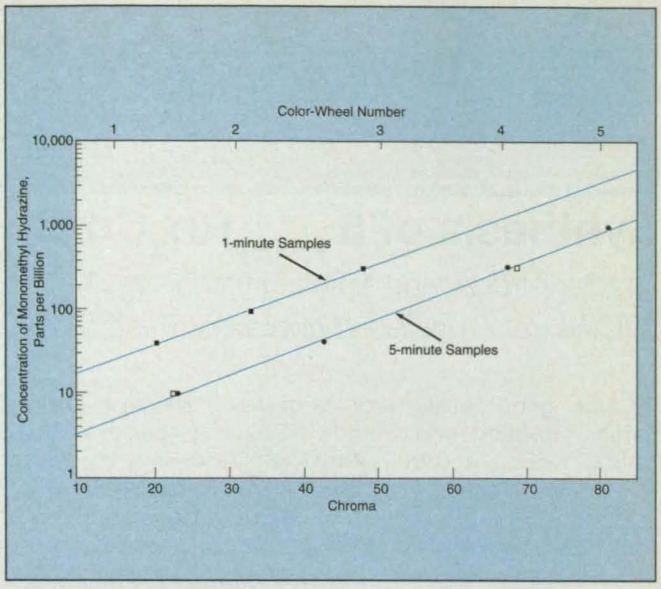


Figure 2. These **Calibration Plots** were established using a sample rate of 2 L/min, with color measured 1 min after completion of exposure.

dow and is intended for sampling through small openings to detect leaks.

In preparation for use, the appropriate badge holder is attached to the pump. Next, a badge is removed from its packet, inserted, and clamped in the badge holder. Then the pump is turned on for an appropriate amount of time to take the sample. The recommended sampling time to detect concentrations of about 10 parts per billion is 5 minutes; shorter sampling times can be used at higher concentrations.

After sampling, the badge is removed, and its color is compared with the colors on a calibrated estimator — a color wheel card preprinted with five shades of yellow that correspond to concentrations of HZ and MMH. Using the sampler and color wheel, the concentration of HZ or MMH can be estimated in the field. For a more precise determination, the exposed badge can be taken back to the laboratory for quantitative measurement of its color by a chroma meter followed by comparison of the chroma reading with a calibration plot of concentration vs. chroma (see Figure 2).

Figure 1. The **Hydrazine-Vapor Sampler** is a lightweight unit that can be carried in the field. The badge holder on this unit is of the open-face design.

This work was done by Rebecca Young of **Kennedy Space Center** *and Charles McBrearty, Dan Curran and Nilgun Leavitt of I-Net, Inc. For further information,* ***write in 103*** *on the TSP Request Card. KSC-11616.*

Synthesis of $Ir_{1-x-y}Rh_xCo_ySb_3$ Semiconductors

Gradient-freeze and sintering techniques have been used.

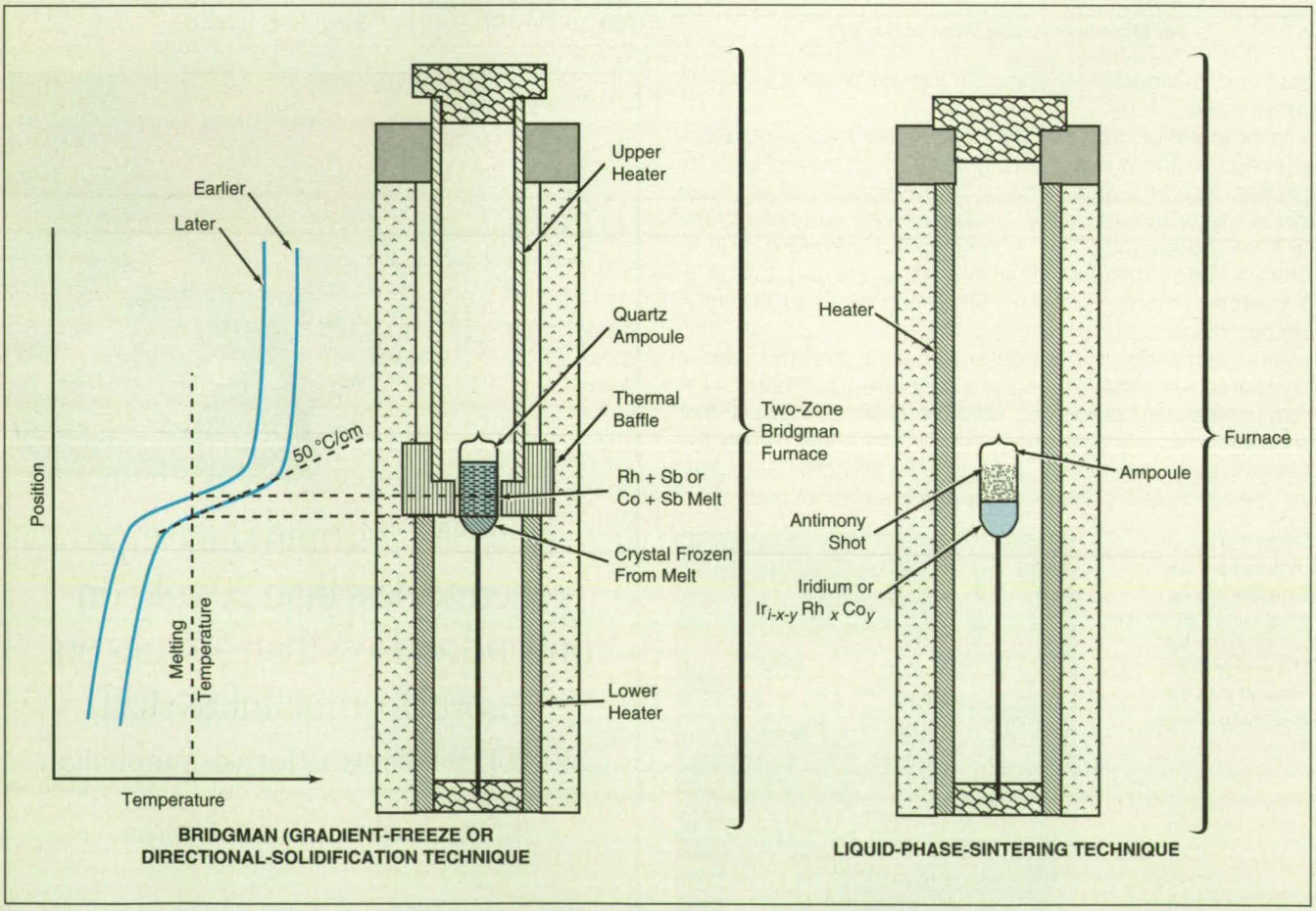
NASA's Jet Propulsion Laboratory, Pasadena, California

Large, good-quality samples of the semiconducting compounds $IrSb_3$, $RhSb_3$, $CoSb_3$, and $Ir_{1-x-y}Rh_xCo_ySb_3$ have been synthesized. These compounds were chosen, via a literature search and theoretical considerations, as candidate materials for new high-performance thermoelectric devices [see also the companion article, "High-Performance Thermoelectric Semiconductors" (NPO-19233)].

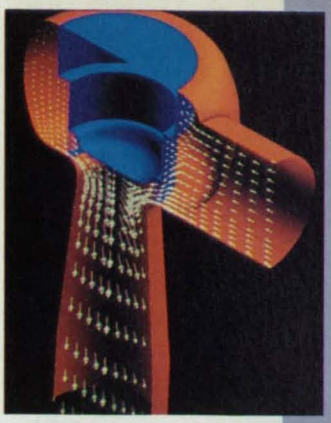
The figure illustrates the two main techniques used in experimental syntheses of these compounds. Single-crystal ingots of $RhSb_3$ and $CoSb_3$ 10 mm long and 6 mm in diameter were grown by the gradient-freeze technique (also known as the directional-solidification or Bridgman technique): Nonstoichiometric (antimony-rich) compositions of the elemental constituents were sealed under vacuum in a quartz ampoule, which was held vertical and stationary in a Bridgman furnace during melting and subsequent directional solidification. The axial (vertical) temperature gradient was about 50 °C/cm and the rate of growth was about 1 mm/day.

The growth of $IrSb_3$ crystals from melts is very difficult and can be initiated only from within a narrow range of compositions. It is also difficult to separate the liquid and solid phases during crystallization. Attempts to grow $IrSb_3$ by the gradient-freeze technique failed. However, a liquid-phase-sintering technique proved successful in repairing not only $IrSb_3$ but also $Ir_{1-x-y}Rh_xCo_ySb_3$ solid solutions. In this technique, powders in the desired proportions of Ir, Rh, and Co were mixed, combined with a stoichiometric or nonstoichiometric proportion of antimony shot, and sealed under vacuum in a quartz ampoule. Experiments showed that heating the ampoule to a temperature of 1,000 °C for 24 h yielded the best (densest) specimens, which contained only the single phase $IrSb_3$ or $Ir_{1-x-y}Rh_xCo_ySb_3$.

It has also been shown that a powder of $Ir_{1-x-y}Rh_xCo_ySb_3$ can be made by mixing powders of the elemental constituents in the desired proportions, then sintering the mixture for as short a time as 6 h at a



$Ir_{1-x-y}Rh_xCo_ySb_3$ Semiconductors Have Been Synthesized by gradient-freeze and sintering techniques. The sintering techniques can be used for a variety of compositions; the gradient-freeze technique can be used for $RhSb_3$ and $CoSb_3$.



Velocity vectors reveal flow patterns through the center section of this steam turbine inlet throttle valve.

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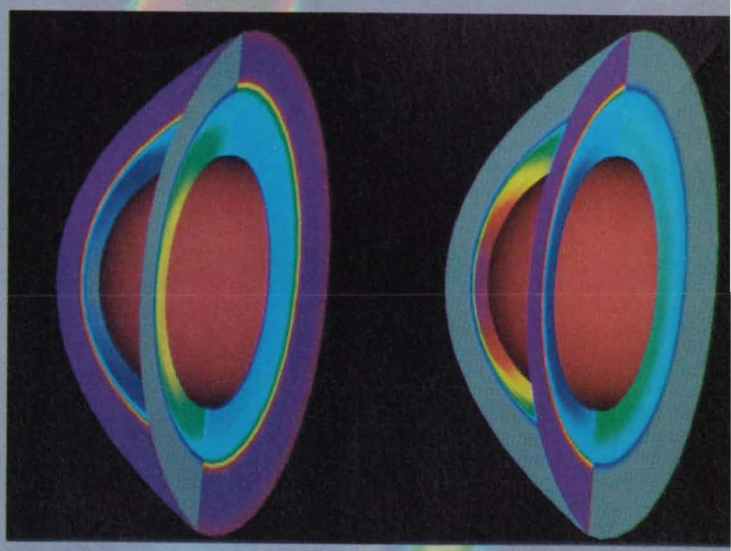

Pressure and Mach number distribution around a 3D blunt body at Mach 10, angle-of-attack = 5°.

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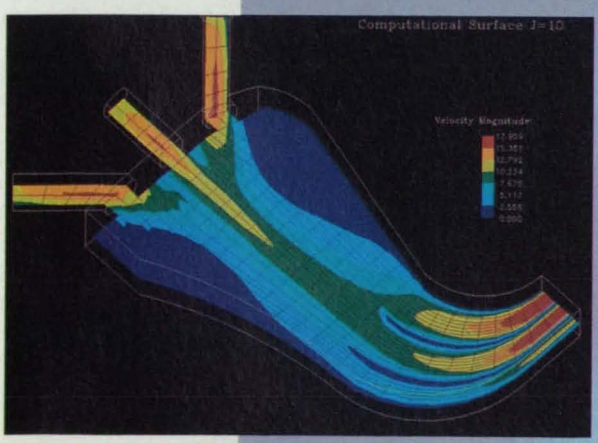

Velocity magnitude on center plane through a multi-port transition duct.

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temperature of 600 °C. High rates of diffusion are likely to be responsible for completion of the sintering chemical reactions in such a short time. The product could be doped by including the appropriate proportion of dopant powder at the mixing stage. The sintered powder can be hot-pressed to form ingots. This process is relatively quick and cheap and can be adapted easily to industrial production of large quantities of $Ir_{1-x-y}Rh_xCo_ySb_3$ of various compositions and doping levels for the development of thermoelectric devices.

This work was done by Thierry Caillat, Alexander Borshchevsky, and Jean-Pierre Fleurial of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 58*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: William T. Callaghan, Manager, Technology Commercialization; JPL-301-350; 4800 Oak Grove Drive; Pasadena, CA 91109.

Refer to NPO-19234, volume and number of this NASA Tech Briefs *issue, and the page number.*

Modified LaRC™-IA Polyimides

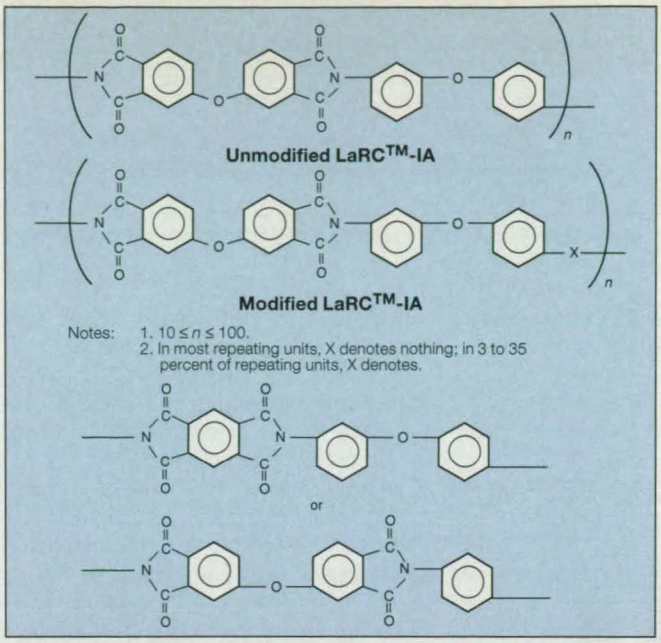
Glass-transition temperatures and resistances to solvents are increased.

Langley Research Center, Hampton, Virginia

Modified versions of the thermoplastic polyimide LaRC™-IA incorporate various amounts of additional, rigid moieties into the backbones of the LaRC™-IA molecules (see figure). In comparison with the unmodified LaRC™-IA, the modified versions are more resistant to solvents and exhibit higher glass-transition temperatures, yet they retain the melt-flow processability of unmodified LaRC™-IA. Modified LaRC™-IA polyimides can be prepared in the form of poly(amic acid) resins (which must be thermally cured to convert them to final polyimide form) or in polyimide form as semicrystalline powders that exhibit excellent melt flow at temperatures in the vicinity of 330°C. The combination of melt flow and resistance to solvents makes these materials attractive as molding powders, spun fibers, and matrix resins for many potential applications.

Unmodified LaRC™-IA has been synthesized from 3,4′-oxydianiline (3,4′-ODA) and 4,4′-oxydiphthalic anhydride (4,4′-ODPA) at 15 weight percent solids content in a solution of γ-butyrolactone. In synthesizing a modified LaRC™-IA, one replaces between 3 and 25 mole percent of 4,4′-ODPA with pyromellitic dianhydride (PMDA), which has a rigid molecular structure. Alternatively, one replaces between 3 and 25 mole percent of 3,4′-ODA with paraphenyldiamine (*p*-PDA). The solvent can also include glacial acetic acid (as a dehydrating agent), or one can use N-methylpyrrolidinone instead of γ-butyrolactone. The molecular weight of the resulting polyimide is controlled by using a slight excess of amine and reacting this excess with monofunctional phthalic anhydride.

For example, in one experimental synthesis, 25 mole percent of 4,4′-ODPA was replaced with PMDA, and 3,4′-ODA was present in about 3 mole percent excess. The resulting polyimide powder had a glass-transition temperature of 233.2°C, a melting temperature of 287.0°C, a heat of fusion of 24.7 J/g, and a melt viscosity of 81,464 poises at 330°C. Films made of this polyimide exhibited increased resistance to solvents. The glass-transition temperature increased to 253.3°C after curing for 1 h at 371°C.



In a **Molecule of Modified LaRC™-IA**, 3 to 25 percent of the repeating units contain extra moieties.

This work was done by Terry L. St. Clair of **Langley Research Center**, *Alice C. Chang and Tan H. Hou of Lockheed Engineering & Sciences Co., and Dennis C. Working of Analytical Services & Materials, Inc. For further information,* ***write in 86*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-15083.

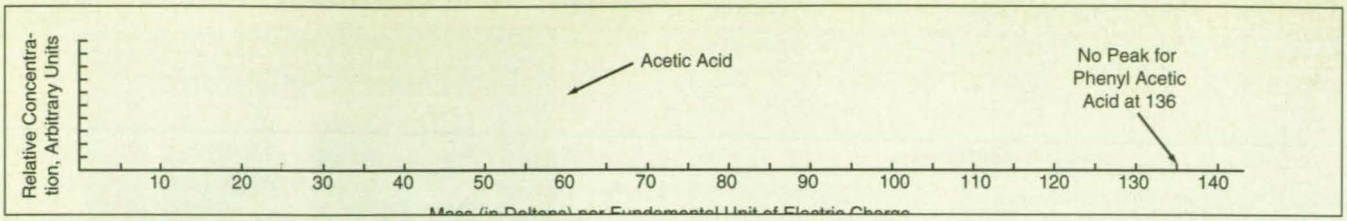
Hydrophobic Porous Material Adsorbs Small Organic Molecules

Lightweight organic contaminants could be removed from gaseous and vacuum environments.

NASA's Jet Propulsion Laboratory, Pasadena, California

A composite molecular-sieve material has a pore structure designed specifically for preferential adsorption of organic molecules that have sizes ranging from 3 to 6 Å: this design is based on the principle that contaminant molecules become strongly bound to the surface of an adsorbent when the size of the contaminant molecules is nearly the same as that of the pores in the adsorbent. The material could be used to remove small organic contaminant molecules from vacuum systems or from enclosed gaseous environments like closed-loop life-support systems.

Heretofore, zeolites with pore sizes of the order of 10 Å have been used in space environments to remove contaminant small organic molecules. Although zeolites are effective for this purpose, they also take up large amounts of water vapor. Therefore, zeolites exposed prematurely to appreciable amounts of mois-



This **Mass-Spectrometer Reading** of gases desorbed from the specimen was taken when the temperature of the specimen reached 250 °C.

ture (e.g., by storage in humid air) before installation in sorbent beds may take up so much water as to lose capacity for subsequent adsorption of organic contaminants. Other disadvantages of zeolites are that they shed particles of themselves and that some zeolites are not thermally stable at temperatures above 400 °C.

The present molecular-sieve material is expected to adsorb organic molecules strongly and not to adsorb water because it is a composite of a carbon molecular-sieve material and a commercial molecular-sieve material (Linde Silicalite S-115 or equivalent), both of which are hydrophobic and organophilic. The composite sorbent material is made by (1) crushing 5 parts by weight of the Silicalite to a fine powder, (2) mixing the powdered Silicalite with 6 parts by weight of polyfurfuryl alcohol to a pastelike consistency, and (3) pyrolyzing the pastelike mixture by heating it in flowing nitrogen, gradually increasing the temperature to 600 °C and then maintaining 600 °C for 3 h. The pyrolyzed material is cooled to room temperature in flowing nitrogen and stored in a sealed container until it is to be used as a sorbent.

Visual examination and a test of crush strength showed that in comparison with zeolites and with carbon molecular-sieve materials, the composite sorbent is stronger and generates less particulates. To test its sorbent characteristics, a specimen of the composite material was exposed to vapors of acetic acid (characteristic size less than 4.3 Å, molecular weight 60 daltons) and phenylacetic acid (characteristic size greater than 6.0 Å, molecular weight 136 daltons). The specimen was then heated up to 400 °C to desorb what had been adsorbed, and the resulting emissions were monitored with a mass spectrometer. The output of the mass spectrometer included a peak for acetic acid but not for phenylacetic acid (see figure); this is consistent with the expectation that the phenylacetic acid molecules would not be adsorbed because they are too large.

This work was done by Pramod K. Sharma and Gregory S. Hickey of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 87*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to William T. Callaghan, Manager; Technology Commercialization; JPL-301-350; 4800 Oak Grove Drive; Pasadena, CA 91109.

Refer to NPO-19129, volume and number of this NASA Tech Briefs *issue, and the page number.*

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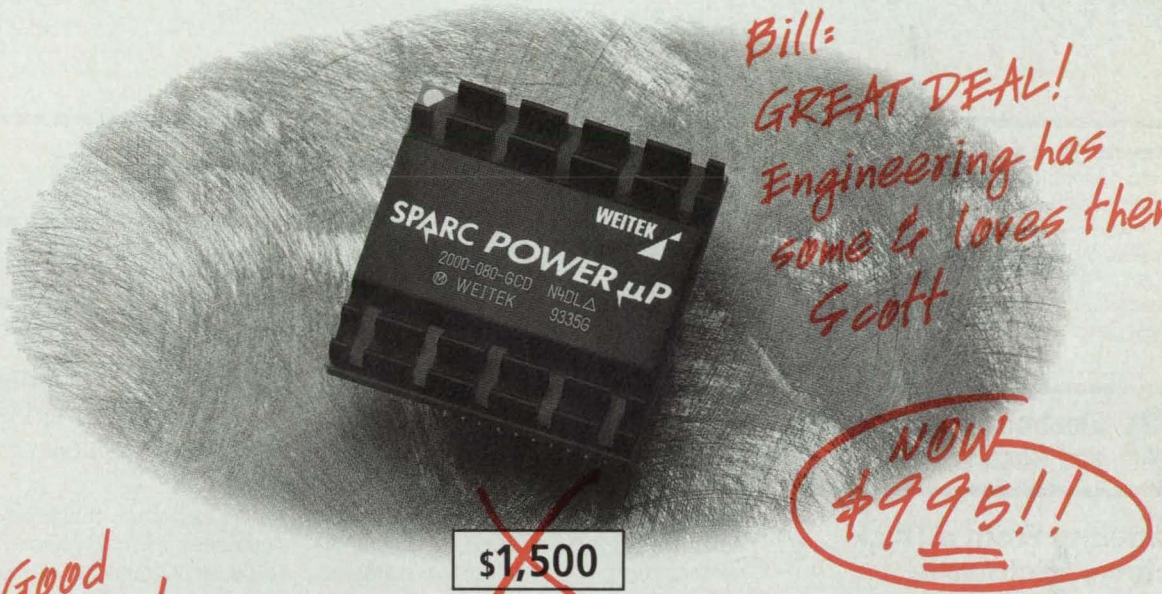

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Electronic Components and Circuits

Scattering From a Thick Dichroic Microwave Reflector

An integral equation is transformed into a matrix equation, which is then solved.

The Thick Frequency Selective Surface with Rectangular Apertures (TFSSRA) computer program was developed to calculate the scattering parameters of a thick frequency-selective surface with rectangular apertures on a skew grid at an oblique angle of incidence. ("Frequency-selective surface" denotes a reflector, usually intended for use with microwaves, that consists of a sheet of electrically conductive material interrupted by gaps and/or apertures in a pattern that imparts frequency selectivity.) In TFSSRA, the method of moments is used to transform an integral equation into a matrix equation suitable for evaluation on a digital computer. TFSSRA predicts the reflection and transmission characteristics of a thick frequency-selective surface for both transverse electric (TE) and transverse magnetic (TM) orthogonal linearly polarized waves.

A mathematical model of a half-space infinite array is used in the analysis. A complete set of basis functions with unknown coefficients is developed for the waveguide region (waveguide modes) and for the free-space region (Floquet modes) in order to represent the electromagnetic fields. To ensure the convergence of the solutions, the number of waveguide modes is adjustable.

The method of moments is used to compute the unknown coefficients of the modes. Then the scattering matrix of the half-space infinite array is calculated. Next, the reference plane of the scattering matrix is moved half a plate thickness in the -*z* direction, and a frequency-selective surface of finite thickness is synthesized by positioning two plates of half thickness back to back. The total scattering matrix is obtained by cascading the scattering matrices of the two half-space infinite arrays.

TFSSRA is written in FORTRAN 77 with single precision. It has been successfully implemented on a Sun4-series computer running SunOS, an IBM-PC-compatible computer running MS-DOS, and a Cray computer running UNICOS; with slight modifications, it should also run on other computers. Double precision is recommended for running on a PC if many modes are used or if high accuracy is needed. This software package requires the LINPACK math library, which is included. TFSSRA requires 1MB of random-access memory for execution. The standard distribution medium for this program is one 5.25-in. (13.335-cm), 360K diskette in MS-DOS format. It is also available on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. This program was developed in 1992 and is a copyrighted work with all copyright vested in NASA.

This program was written by Jacqueline C. Chen of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 82*** *on the TSP Request Card. NPO-18806.*

Mechanics

Eliminating Computational Instability in Multibody Simulations

TWOBODY implements an improved version of the Lagrange multiplier method.

The Lagrange multiplier method has been used for many years by engineers to develop equations of motion in multibody problems. The use of Lagrange multipliers offers an advantage over some other formulations in that it preserves the original simple form of the equations of motion for each body. However, in typical simulations of time-varying dynamics by use of Lagrange multipliers, computational instabilities can occur because integration errors cause two (or more) attached bodies to drift apart and violate the constraints. The computational instability usually happens suddenly, and the computed values "blow up" within a few time steps.

The TWOBODY computer program utilizes a programming technique that eliminates computational instability in multibody simulations in which Lagrange multipliers are used. In this technique, one uses the constraint equations, instead of integration, to determine the coordinates that are not independent. To illustrate the technique, TWOBODY includes a simple mathematical model of a solid rocket booster and a parachute connected by a frictionless swivel.

TWOBODY is written in FORTRAN 77 for IBM PC-series and compatible computers running MS-DOS. It requires 100K of random-access memory for execution. A sample executable code is included with the distribution medium. The stand-

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ard distribution medium for this program is one 5.25-in. (13.34-cm), 360K, MS-DOS-format diskette. The program was developed on a 486/D33 workstation with Ipi FORTRAN in 1992.

This program was written by Gaines L. Watts of **Marshall Space Flight Center**. *For further information,* ***write in 15*** *on the TSP Request Card. MFS-28774.*

Physical Sciences

Computing Temperatures and Pressures Along Heat Pipes

Given boundary conditions, LERCHP models steady-state thermal behavior.

The NASA Lewis Research Center Heat Pipe (LERCHP) computer code was developed to predict the performances of heat pipes in the steady state. LERCHP can be used as a design software tool on a personal computer or, with a suitable calling routine, as a subroutine for a mainframe-computer radiator code. For accurate mathematical modeling of heat pipes, LERCHP makes a variety of wick structures available to the user; optionally, the user can specify wick structures via input data. The user can also choose among several working fluids, including potassium, sodium, and lithium, for which the monomer/dimer equilibrium is considered. A vapor-flow algorithm in the program treats compressibility and axially varying heat input. LERCHP also facilitates the determination of heat-pipe operating temperatures and heat-pipe limits that may be encountered at the specified heat input and environmental temperature.

LERCHP has been written for straight, cylindrical heat pipes that have no bends. Simple modification to non-circular cross sections could be achieved by use of the hydraulic-radius approach, but this feature is not currently implemented. Curvature without sharp bends is permissible. The program accounts for operation of straight pipes in gravitational fields but does not provide for modeling of thermosyphons.

Heat pipes with multiple evaporators, condensers, and adiabatic sections in series and with wick structures that differ among sections can be modeled by LERCHP. A heat pipe can be subdivided into as many as 20 sections, far more than will normally be required. These sections can be heat-input or evaporator sections, adiabatic sections, and heat-removal or condenser sections, mixed in any manner, provided that the first section is a heat-input section.

The nature of any section is indicated by the type of boundary condition data that are entered for that section. At present, the following options for boundary conditions are available: (1) specified heat-input or removal rate at the exterior surface of the pipe and (2) specified temperature of the environment outside the pipe, with conditions for the transfer of heat from the surface of the pipe to the environment provided by the user.

For each section, the required data can be entered as single values that pertain to the entire section. Values of the input parameters can also be entered at as many as 20 points spaced along the section, with a different magnitude at each point, interpolated by spline fit. Computations along the pipe are made by a Runge-Kutta routine for which the initial step size is chosen, with automatic decrease or increase as the slope of the principal dependent variable, pressure, exceeds or falls below certain bounds. Data are entered by means of an interactive subroutine that queries the user concerning the options to be employed in the case to be run.

The printed output consists of such information as liquid and vapor pressures and temperatures at axial positions spaced equally along the pipe. LERCHP allows the user to select the number of such points. The spacing of these points need not correspond with the step size chosen for the Runge-Kutta solution. A printout is furnished after thermal convergence of the solution has been obtained. When a heat-pipe limit is encountered during calculation of the solution, but does not cause the calculation to halt, the type of limit is printed out with the solution. Output can be directed to a plotting device if a suitable plotting utility program is available and the necessary changes are made in the source code.

LERCHP is written in FORTRAN 77 for IBM PC-series and compatible computers running MS-DOS. The standard distribution medium for this program is one 5.25-in. (13.34 cm), 360K MS-DOS-format diskette. LERCHP was developed in 1992.

This program was written by K. W. Faker and T. S. Marks of **Lewis Research Center** *and L. K. Tower of Sverdrup Technology, Inc. For further information,* ***write in 93*** *on the TSP Request Card. LEW-15625.*

Array of Probes to Measure Static Pressure and Turbulence

Shapes and arrangements are chosen to emphasize desired components of fluctuating pressures.

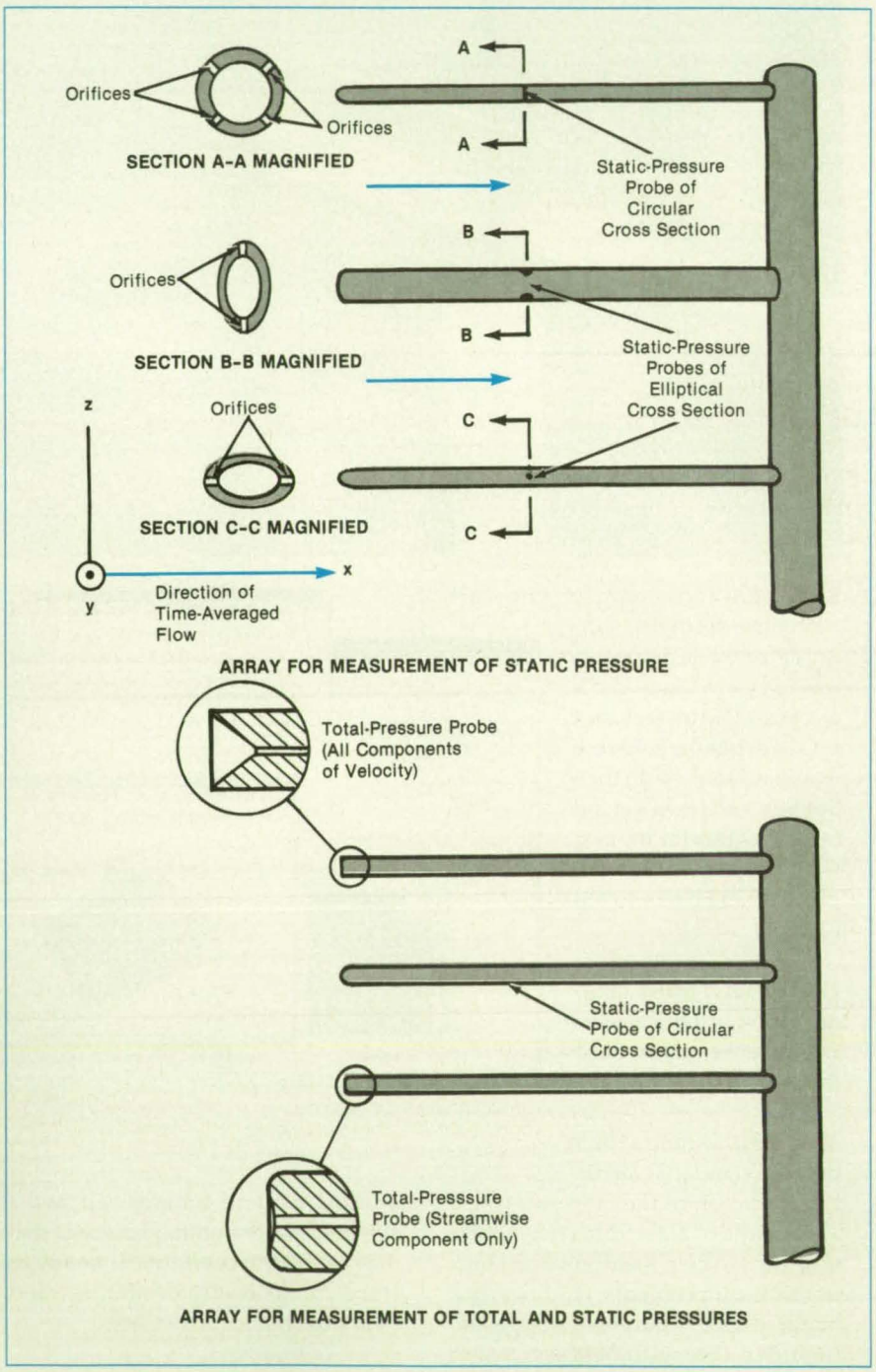
Ames Research Center, Moffett Field, California

Rakelike arrays of tubular pressure probes can compute the time-averaged static pressures and, in some cases, the time-averaged intensities of cross-stream turbulence of incompressible (or, equivalently, low-subsonic), inviscid flows. The probes in those arrays are descendants of the Pilot and Prandtl tubular pressure probes shaped to obtain specified directional responses.

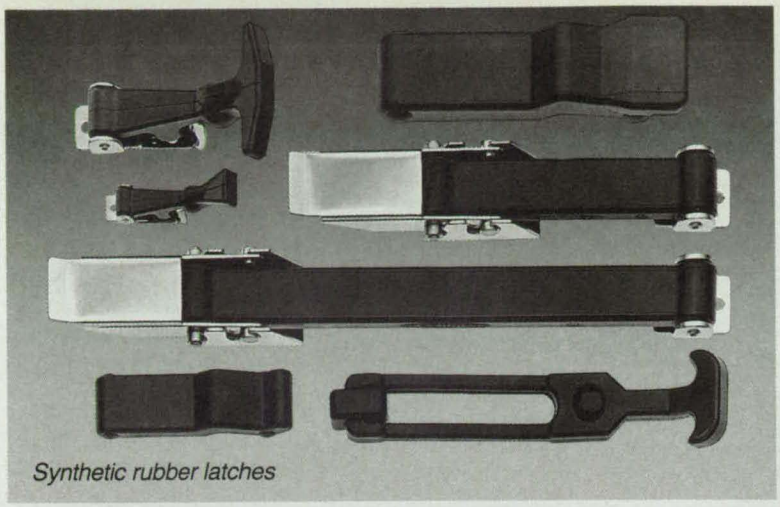
It is assumed that a tubular probe of the type in question is oriented along the streamwise (x) direction of time-averaged flow. The static-pressure orifices are located on the sides of the probe downstream from the tip. The application of potential-flow theory to the flow in the vicinity of the probe shows that the time-averaged pressure measured at each static-pressure orifice is really a dynamic pressure that consists of the static pressure plus terms proportional to the time-averaged squares of the fluctuating (turbulent) cross-stream (y and z) components of velocity.

The shape of the cross section of the probe (as viewed along the x axis) and the distribution of orifices around the circumference of the cross section affect the constants of proportionality; they can be chosen by design to obtain a specified degree of enhancement of the measurement sensitivity to a specified component of the crossflow. For example, if the probe tube has an elliptical cross section and orifices are located on the major axis of the ellipse, then the pressured measured at the orifices are enhanced by an amount proportional to the square of the ellipticity and to the square of the component of velocity along the minor axis.

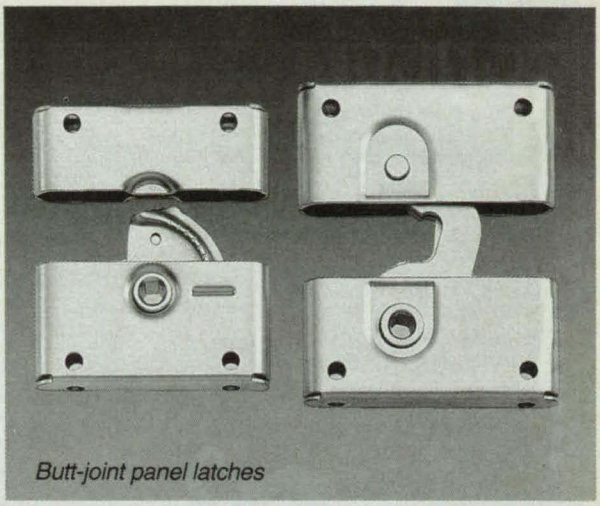
The directional responses of three different static-pressure probes can be designed so that when the probes can be designed so that when the probes are mounted in an array (see upper part of figure) to sample the same flow, their outputs can be combined mathematically to eliminate the unknown quantities and compute the time-averaged static pressure. The validity of the design of the array and of combination of measurements depends on the following simplifying assumptions:



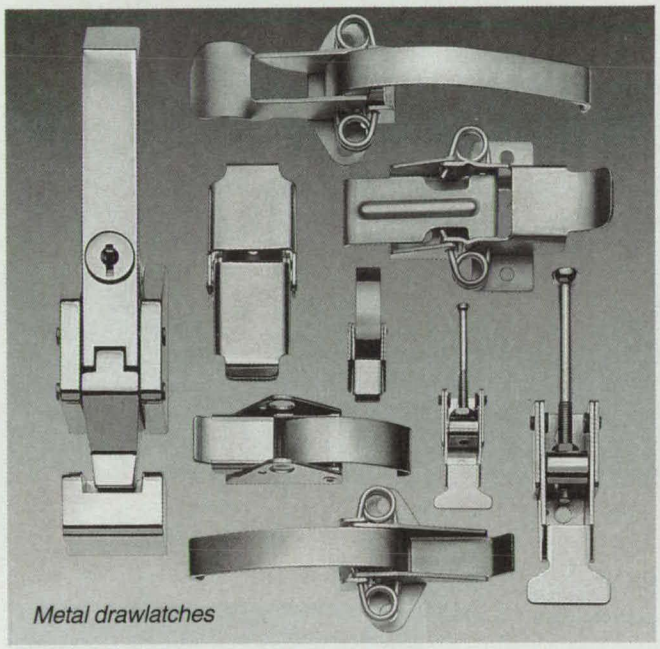
Arrays of Pressure Probes are designed with cross sections and orifices that impart specified directional responses to dynamic pressures, such that one can extract the time-averaged static pressure from the measurements.



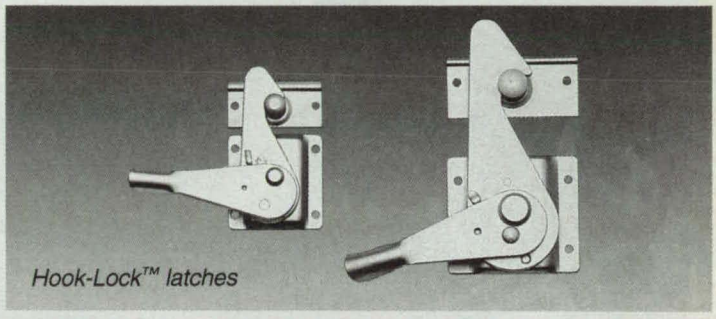
Synthetic rubber latches



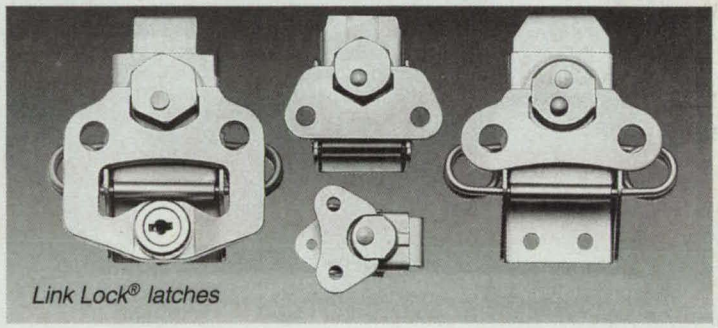
Butt-joint panel latches



Metal drawlatches



Hook-Lock™ latches



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the probes remained aligned along the time-averaged streamwise direction; the time-averaged characteristics of the flow do not vary appreciably from the location of one probe to the location of another probe; and no probe significantly perturbs the flow in the vicinity of the orifices of another probe.

One can also obtain redundant measurements to verify the accuracy and consistency of the foregoing determination of static pressure: These measurements can be made with a three-probe array (see lower part of figure) that includes a static-pressure probe of circular cross section plus two total-head probes that yield data on the cross-stream turbulence. A larger array consisting of both of the preceding arrays could be used to obtain redundant values of the time-averaged static pressure and cross-stream turbulence, plus time-averaged values of the streamwise and entire stagnation pressures.

This work was done by Vernon J. Rossow of **Ames Research Center**. *For further information,* ***write in 6*** *on the TSP Request Card.*

This invention owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center [see page 20]. Refer to ARC-12973.

Acoustic Diagnosis of Faulty Dynamic-Pressure Sensors

A new use for a particle-impact-noise detector is found.

Marshall Space Flight Center, Alabama

Dynamic-pressure sensors and accelerometers that tend to produce spurious readings can be identified with the help of a particle-impact-noise detector (PIND), a device that is used in the electronics and packaging industries to detect loose particles inside components. A PIND includes an acoustic-emission sensor integral with a vibration head. The pressure sensor, accelerometer, or other unit to be tested

is mounted on the head. The PIND then produces a programmed series of vibrations and/or shocks: impacts of loose particles inside the unit under test are detected by the acoustic-emission sensor, the output of which is displayed on an oscilloscope.

Usually, a unit to be tested is mounted on the PIND in three different orientations and subjected to the complete series of vibrations and/or shocks in each orientation. A test series typically includes vibrations with amplitudes of 5 and 10 times normal gravitational acceleration, frequencies of 40 and 100 Hz, and one or more shock(s) at 200 times normal gravitational accelerations. Each combination of amplitude and frequency is typically maintained for 6 s.

This work was done by Martha P. Willis and Jon B. Tracy of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 102*** *on the TSP Request Card. MFS-29982.*

Streaks of Colored Water Indicate Surface Airflows

Response is faster and contamination is less than in the oil-flow technique.

Langley Research Center, Hampton, Virginia

Flowing colored water provides an accurate and clean way to reveal flows of air on the surfaces of models in wind tunnels. The colored water flows from small orifices in a model, forming streak lines under the influence of the air streaming over the surface of the model.

The flowing-colored-water technique has important advantages over the older oil-flow technique, in which the model is coated with colored or fluorescent oil. The oil tends to contaminate downstream instrumentation as it is blown off the model. Tests may have to be interrupted periodically to replace the lost oil. Moreover, because oil is highly viscous, it responds slowly to aerodynamic changes. Colored water, in contrast, is relatively noncontaminating and responds quickly. Furthermore, the water is replenished continuously through the orifices. (In many cases, the low pressure on the surface draws the water. However, the water containers can be pressurized where necessary.) In another older technique, short pieces of string or yarn are glued or taped to the surface of the model. The tufting reveals airflow patterns in only a coarse

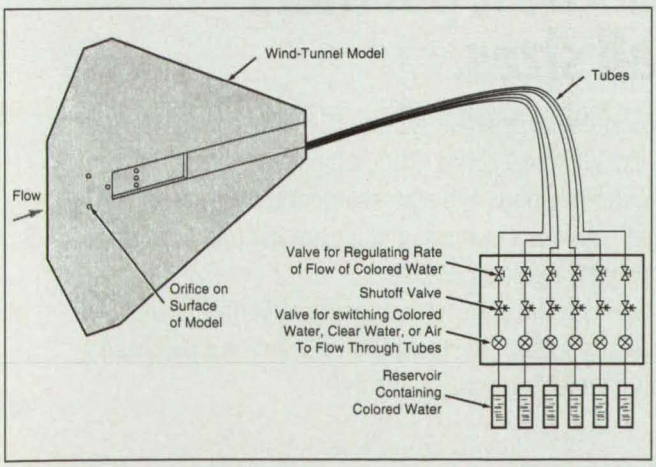

Figure 1. **Colored Water Flows** from orifices on the surface of the model.

Tony and Emma Vargo of VIP Mfg. & Engr. Corp., with a Trident missile snubber plate and another missile actuator housing assembly.

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way, and gives no indication of merging airflows. In addition, tufting can be stripped off by sliding surfaces on the airfoil. Colored water, on the other hand, shows details of flow (including merges), and neither causes nor is subject to mechanical interference.

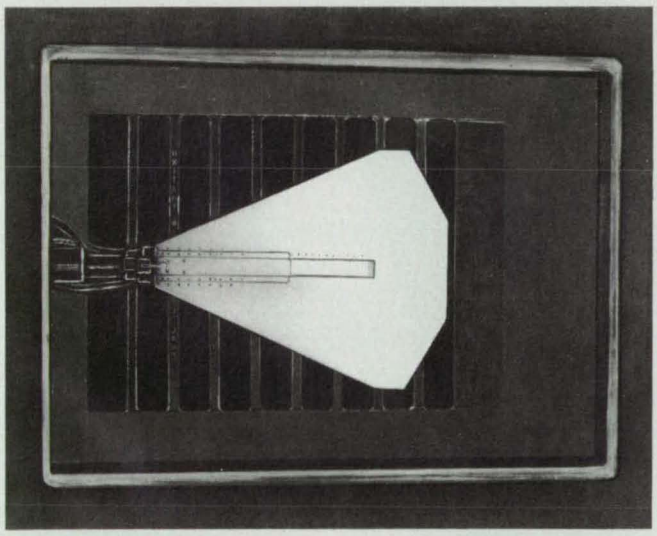
Colored water is easily visible on a white model, and the streaks that represent the airflow pattern can be captured by still or motion photography. Water can be injected in different colors at various locations so that airpaths can be discerned and merging airflows can be identified. For example, surface flows from two different regions, indicated by blue and yellow streaks, can merge to form a green vortex.

The water, which is tinted with ordinary food coloring, is fed from containers through valves and tubes to the orifices (see Figure 1). An operator can adjust the valves to turn the flows on and off, control the rates of flow, and switch among colored water, clear water, and air.

The flowing-colored-water technique was demonstrated in a wind tunnel at supersonic speeds on a model that consisted of a cavity in a flat plate. Colored water was ejected through orifices inside the cavity and on the flat plate. Surface flow patterns were photographed at mach numbers of 1.5 and 2.16 (see Figure 2) while the length of the cavity was varied.

This work was done by Floyd J. Wilcox, Jr., of **Langley Research Center**. *For further information,* ***write in 70*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14823.



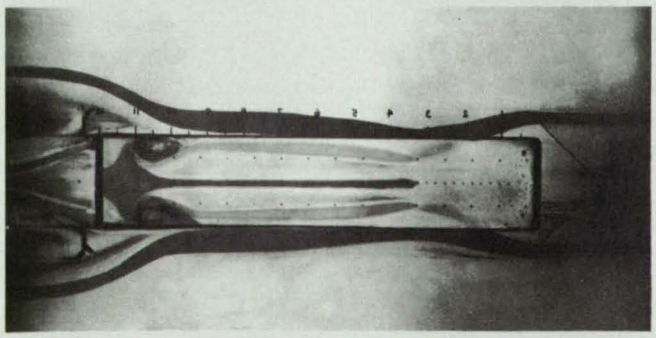


Figure 2. **Streaks Made by Colored Water** reveal airflow patterns on the surface and in the cavity of the flat-plate model.

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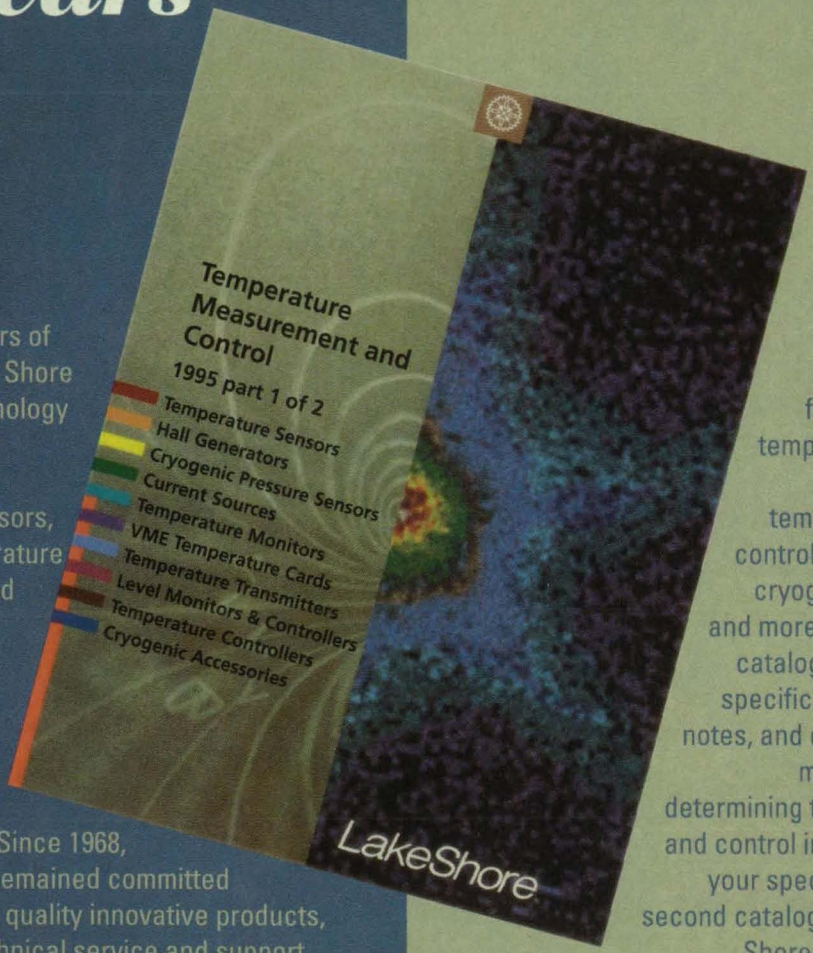

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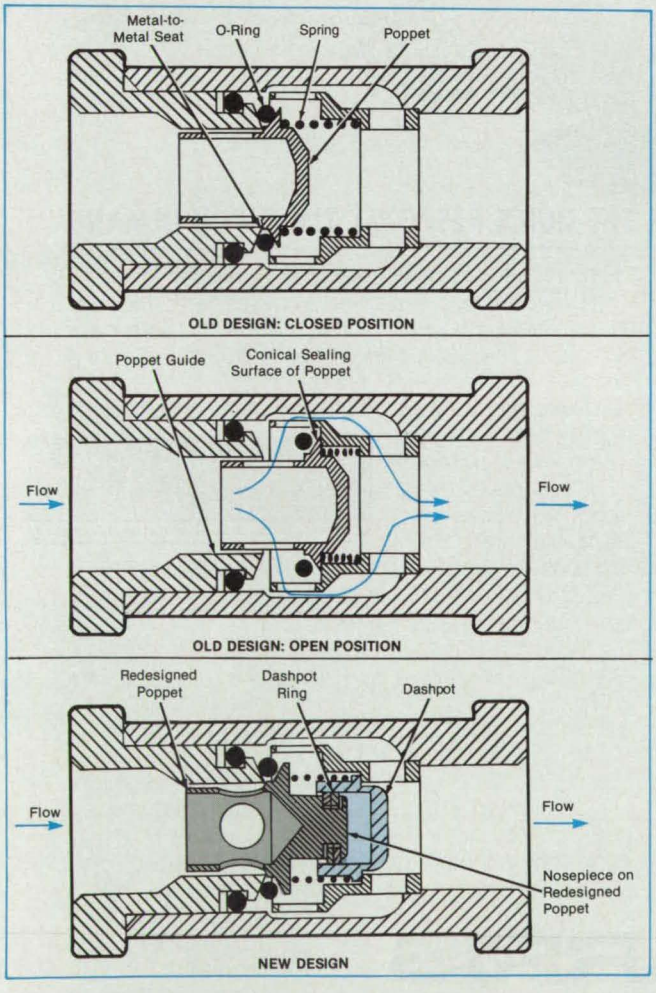
Dashpot Damps Oscillations in Check Valve

Less oscillation means less wear and longer service life.

Lyndon B. Johnson Space Center, Houston, Texas

The operation of a check valve has been improved by redesigning the poppet and adding two new components: a dashpot and a dashpot ring between the dashpot and the poppet. These modifications eliminate the self-sustaining poppet oscillations that cause premature wear and jamming of the poppet mechanism. Check valves that would normally last for years can be ruined in a few hours by oscillations. Moreover, the wear generates particles that contaminate downstream components.

The redesigned poppet includes a nosepiece that rides in the dashpot (see figure). Fluid forced in and out of the dashpot must flow along a tortuous path between the dashpot ring and a groove in the nosepiece. The flow resistance offered by the path creates a differential pressure between fluid in the dashpot cavity and the fluid surrounding the poppet. This difference decelerates the poppet as it moves toward either the closed or the open position and thus tends to damp out oscillations.



The Dashpot Ring is held by friction in the dashpot and fits loosely in the groove of the nosepiece of the redesigned poppet. The poppet compresses fluid in the dashpot cavity as it opens and draws fluid into this cavity as it closes.

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The flow resistance of the dashpot ring depends on the thickness of the ring and the gap between the surfaces of the ring and the surfaces of the groove in the nosepiece. If the ring is cut in a spiral, the flow resistance also depends on the number of turns. If the ring is of the bias-cut type, the flow resistance also depends on the width of the bias-cut gap.

The dashpot ring also offers sliding friction by virtue of its rubbing in the dashpot. This friction depends on the tightness of its fit in the dashpot, the number of turns in the ring, and the ring material (among other things). A low-friction material like polytetrafluoroethylene is a good choice for the ring material.

This work was done by Brian G. Morris of **Johnson Space Center**. *For further information,* ***write in 78*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed by the Patent Counsel, Johnson Space Center [see page 20]. Refer to MSC-21950.

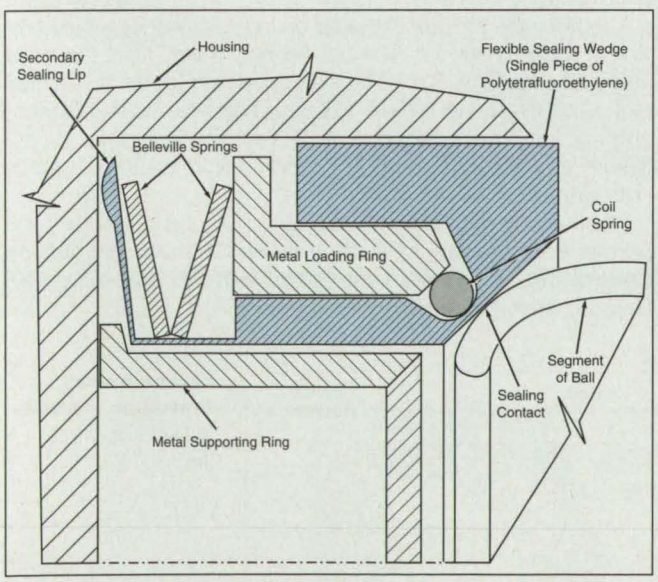
Flexible Wedge Seal for Ball Valve

Less closing force would be needed, and thus a smaller actuator could be used.

Marshall Space Flight Center, Alabama

A proposed ball valve would contain a flexible sealing wedge. The wedge would flex around the ball at the locus of contact, thereby creating an effective seal with less force on the ball than if a hard valve seat were used. Less torque would therefore be needed to close the valve, and a smaller actuator could be used.

Belleville springs would apply an axial force to a metal loading ring within the wedge (see figure). The loading ring would apply a partly radial, partly axial force to an internal spring made of coiled wire or helically wound metal ribbon. The spring would, in turn, force the wedge against the ball.



The **Conical Face of the Sealing Wedge** would form a primary seal at the circle of contact with the ball, while its integral lip would form a secondary seal at the circle of contact with the housing. This view is a partial cross section in the meridional (axial-radial) plane.

The Belleville springs would also press against a lip on the wedge; the lip would, in turn, press against the housing, providing a secondary seal.

The Belleville springs would provide a consistent load despite large variations in the position of the ball with respect to the wedge. The internal coil spring would distribute the load nearly uniformly around the circumference. A metal supporting ring would prevent damage to the thin section of the wedge in the vicinity of the contact with the ball by preventing bending or buckling of the wedge.

This work was done by Joseph A. Levert and Larry M. Gage of Allied-Signal Aerospace Co. for **Marshall Space Flight Center**. *For further information,* ***write in 84*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28907.

All-Metal Tires

These tires would be used where elastomeric and pneumatic tires would not function.

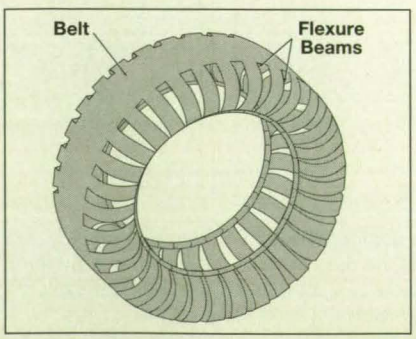
NASA's Jet Propulsion Laboratory, Pasadena, California

Tires composed entirely of metal are being considered for use where conventional elastomeric and pneumatic tires cannot function. Metal tires can withstand extreme temperatures that would destroy rubber-cased, air-inflated tires. The metal tires were conceived for use on a rover vehicle on Mars, where the extremely low temperature precludes rubber or silicone-rubber tires. All-metal tires could be used on Earth for vehicles and robots that fight fires or clean up dangerous chemicals, for example. A prototype metal tire has been successfully tested in an arroyo.

The prototype metal tire (see figure) is made of sheet metal formed into a circumferential belt with thin curved beams (flexure beams) for sidewalls. Cleats (not shown in the figure) are spotwelded to the belt.

The sidewalls provide the radial springiness that air would provide in a pneumatic tire. The belt keeps the tire stiff in tangential and axial directions. The belt resists squirming (distortion on contact with the ground) while it rolls: this helps to ensure efficiency and traction. The dimensions of the belt and beams for proper flexure under a wide range of conditions were computed by finite-element analysis.

This work was done by Donald B. Bickler, Lee F. Sword, and Randel A. Lindemann of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 65*** *on the TSP Request Card. NPO-18859.*



Flexure Beams Constitute the Sidewall of this all-metal tire.

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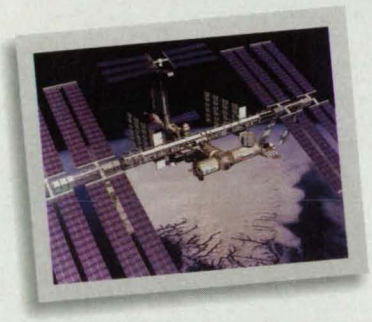

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Marshall Space Flight Center, Alabama

A powerful electromechanical linear actuator has been designed to replace a hydraulic actuator that provides incremental linear movements to a large object and holds its position against heavy loads. The hydraulic actuator and associated equipment are complicated and vulnerable to leaks, and they need considerable maintenance. This electromechanical actuator is cleaner (because there is nothing to leak) and simpler, and needs less maintenance.

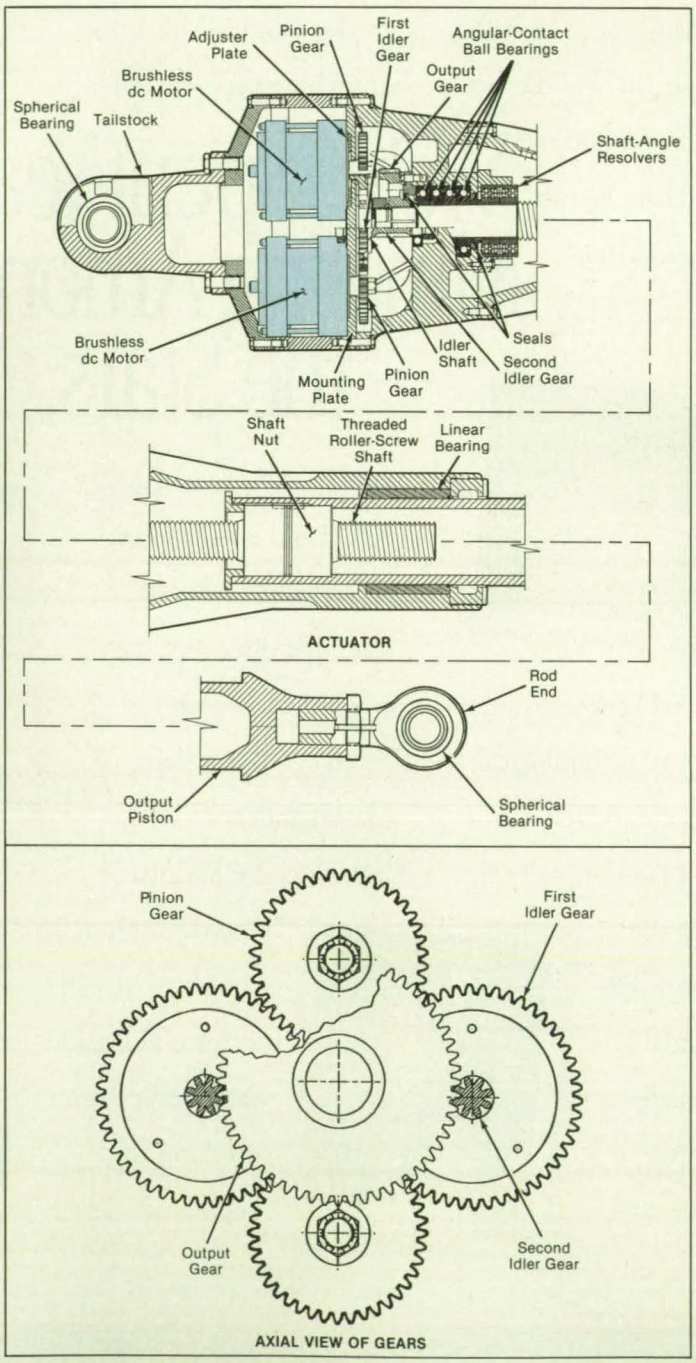
Other electromechanical actuators of similar size and design are available. This electromechanical actuator includes a rotary-to-linear-motion converter. Two brushless dc motors drive a threaded roller-screw shaft via a gear train; a piston attached to a shaft nut travels along the threaded shaft when the shaft is rotated. The two principal innovative features that distinguish the new actuator from prior electromechanical actuators of this type are (1) the use of a shaft-angle resolver (instead of a linear variable-differential transformer) as a source of position feedback to an electronic control subsystem and (2) an antibacklash gearing arrangement.

The actuator (see figure) is attached, with spherical bearings at its ends, to the two objects that are to be moved incrementally with respect to each other. Increments of linear motion are monitored and controlled via the increments of angular motion measured by the shaft-angle resolvers and the known relationship (from gear ratios and thread pitch) between rotation and translation. The antibacklash gearing arrangement, which helps to maintain precision of the increments, is implemented in a special fabrication sequence that includes precise machining and small adjustments.

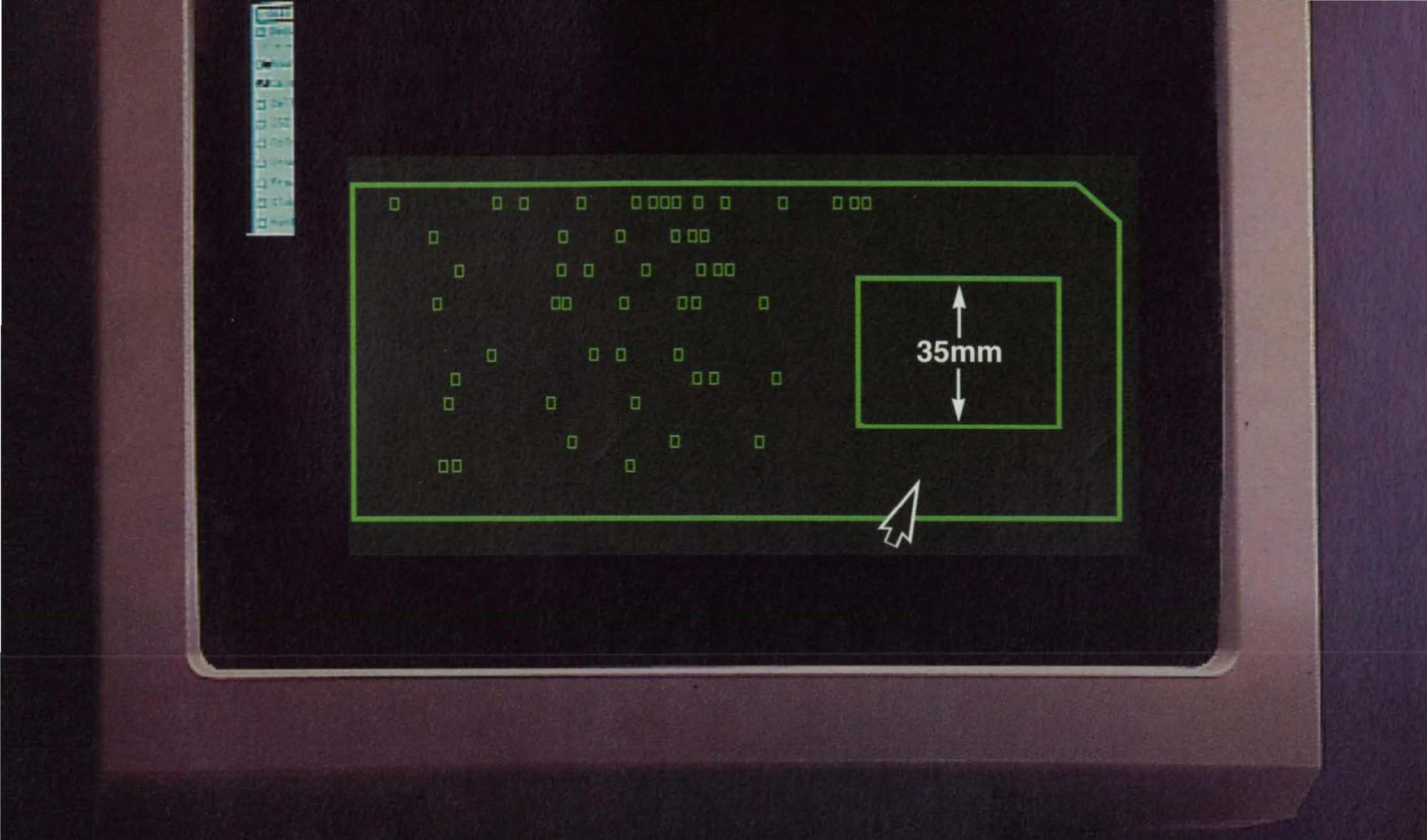
The idler gears, which are parts of the antibacklash gearing, also reduce the speed of rotation of the shaft and increase the torque applied to the output gear. The output gear is keyed to the threaded shaft. The shaft is supported by a quadruplex set of angular-contact ball bearings. Seals prevent the entry of contaminants into the bearings. A linear bearing impregnated with graphite keeps the piston aligned with the axis of linear motion.

This work was done by John R. Cowan and William N. Myers of **Marshall Space Flight Center**. *For further information,* ***write in 47*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-28673.



This **Electromechanical Linear Actuator** features a rotary-to-linear-motion converter with antibacklash gearing and position feedback via shaft-angle resolvers, which measure the rotary motion.



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Two-Way Tether Gun

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Lyndon B. Johnson Space Center, Houston, Texas

A proposed safety-tether device would enable crewmembers on a spacecraft to retrieve a crewmember drifting away from the spacecraft. Alternatively, a drifting crewmember who carries the device could use it to grasp and return to the spacecraft. The device could also be used on Earth. For example, a rescuer on a vessel or pier could use it to retrieve and haul a drowning or unconscious person to safety; a drifting person or a rescuer in the water could use it to grasp and hold onto a support.

The tether device would include a spring-loaded gun fired by a solenoid. The gun would shoot out a tethered shuttle that would deploy a net that would surround the person or object to be grasped (see Figure 1). The shuttle (see Figure 2) would hold several balls at the outer ends of tensioned primary filaments spaced equally around its circumference at its forward end. Each primary filament would be held in tension by winding it in tension on its spool and locking the spool with a pin. The tension would compress a chamber spring that, when released subsequently, would push the balls out.

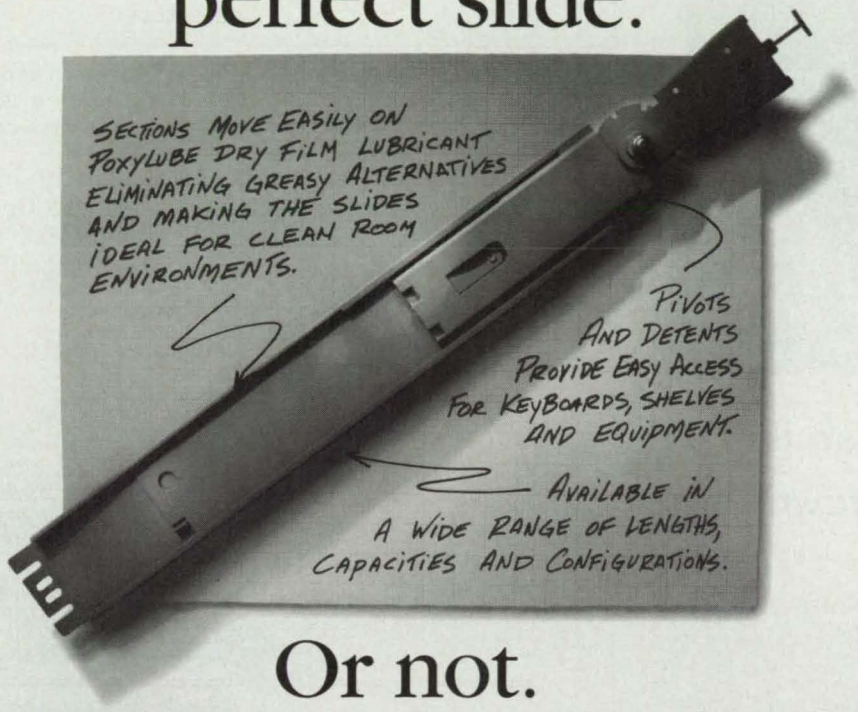
The balls, made of weighted hook-and-pile material (Velcro or equivalent), would be connected by primary filaments wound partly on spools. Each ball would also be attached by secondary filaments to its immediate neighbors. The secondary filaments would be folded in loops on the outside surface of the shuttle and anchored aft by a breakable ring.

The shuttle would be mounted on a compressed spring at the inner end of a launch tube and would be connected to a spool at the inner end of the launch tube by a main tether. To fire the gun, one would activate the solenoid, thereby freeing the shuttle to move outward. The expanding launching spring would eject the shuttle from the tube, and the main tether would be pulled out from the spool at the inner end of the launch tube.

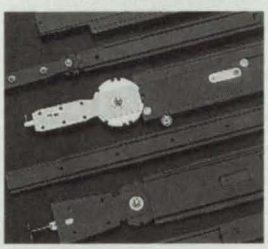
When the shuttle reached the maximum deployed length of the main tether, the sudden tension on the main tether line would pull back a retaining ring in the shuttle, thereby pulling back the pins that lock the primary-filament spools. This would relieve the tension in the primary filaments, allowing the chamber springs to eject the balls, which would carry along with them the net constituted by the primary and secondary filaments. Upon contact with the target, the web would surround the target, and the balls would engage each other, sealing the target within the net. The main tether would then be retracted, drawing the target with it.

The shuttle could be reused. The primary filaments would be rewound on their spools, and the secondary filaments would be draped on the outer surface and resecured with a new breakable ring. The shuttle assembly would then be reinserted in the firing tube and secured on the compressed launching spring.

This may be the perfect slide.



Or not.



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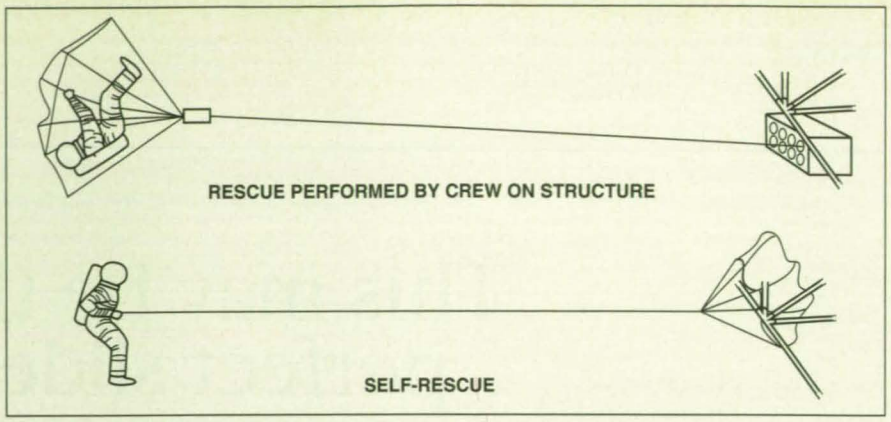


Figure 1. In **Alternative Modes of Operation**, a person could be enveloped in a safety net extended from a structure, or the person could shoot out the tether and net to grasp the structure. Either way, the tether would then be retracted to bring the person to safety at the structure.

The gun would have a range of 20 to 100 ft (6 to 30 m). The ball-and-filament network would be about 12 ft (3.7 m) wide.

This work was done by George F. Sanger of Lockheed Engineering & Sciences Co. for ***Johnson Space Center****. For further information,* **write in 51** *on the TSP Request Card. MSC-22037.*

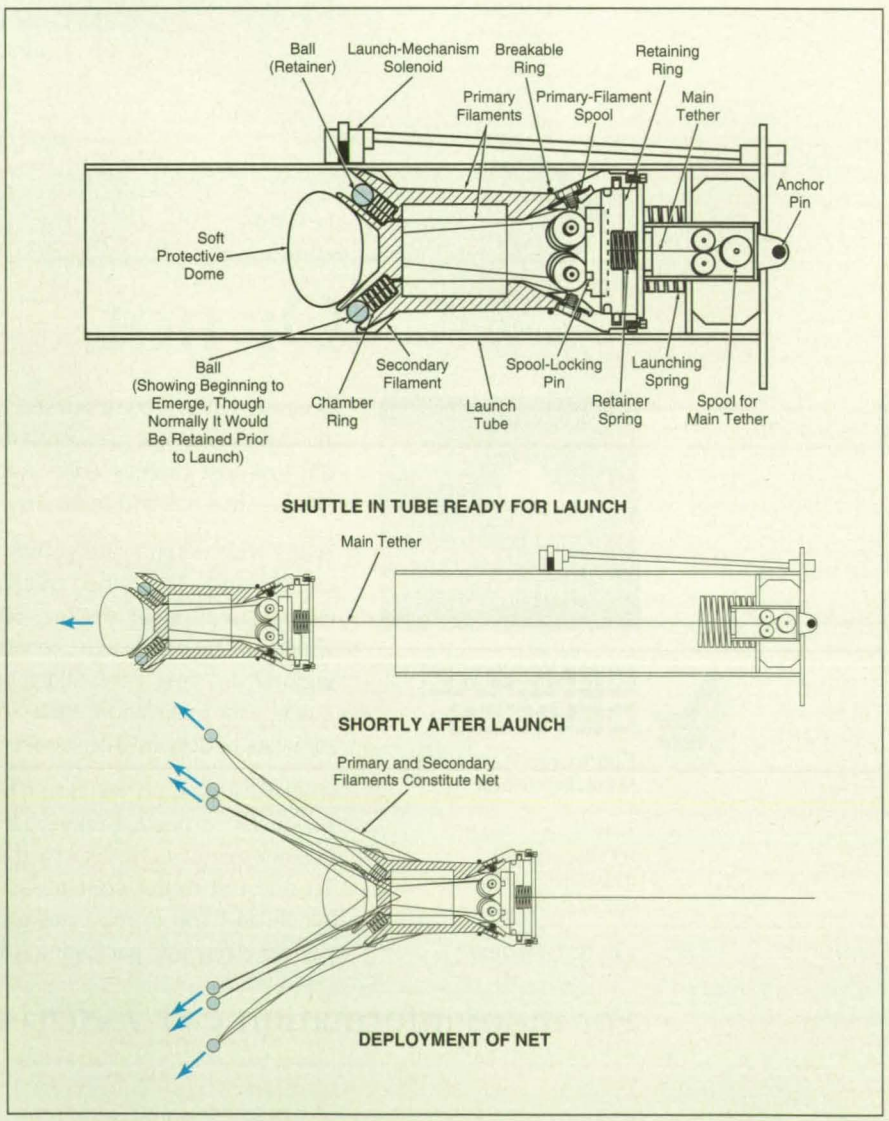


Figure 2. **Initially, the Shuttle Would Be Retained** at the inner end of the launch tube. Upon firing, the launching spring would expel the shuttle. The balls would then be expelled from chambers in the shuttle, deploying the filaments to form a net.

Micromachined Silicon Waveguides

Components that handle millimeter and submillimeter wavelengths will be fabricated conveniently.

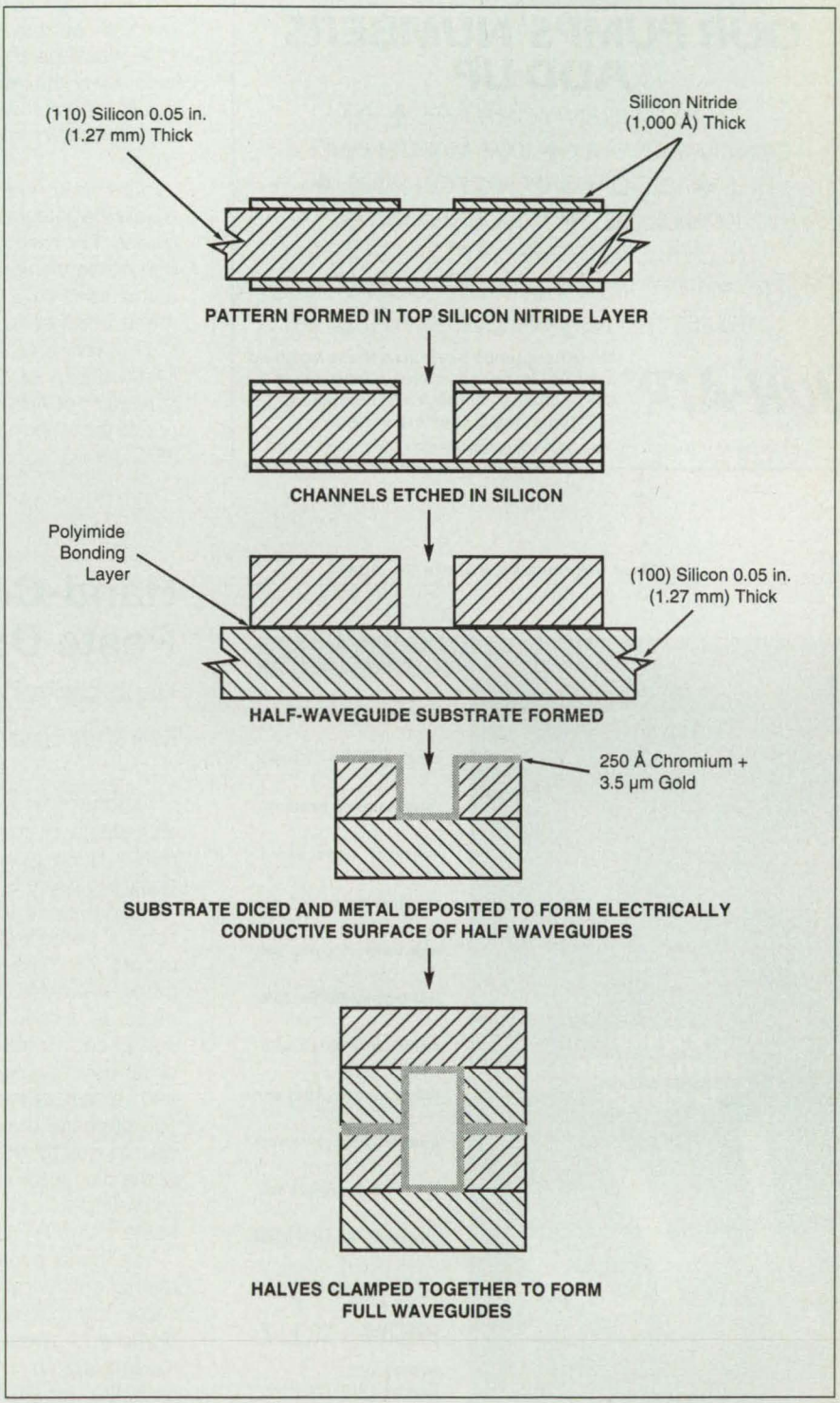
NASA's Jet Propulsion Laboratory, Pasadena, California

Silicon-micromachining techniques are used in continuing efforts to develop waveguides for millimeter and submillimeter wavelengths. The techniques are essentially the same as those used to make micromechanical parts such as sliders, motors, gears, and spiral springs with dimensions of 50 to 200 μm. An intermediate goal of these development efforts is to make waveguides with cross sections as small as 0.3 by 0.15 mm to carry electromagnetic waves with frequencies of 0.5 to 1.0 THz.

Fabrication of such small waveguides in the usual brass and copper by conventional methods is time consuming, costly, and difficult. In addition, mounting active and passive devices on small conventional waveguides is difficult.

As a demonstration of micromachining, a WR-10 waveguide, for frequencies of 75 to 115 GHz, was fabricated. This waveguide had inner channel dimensions of 0.1 in. (2.54 mm) by 0.05 in. (1.27 mm). It was fabricated as two half sections (see figure). The starting material was a silicon wafer with a thickness of 0.05 in. (1.27 mm) and a (110) surface orientation. First, a layer of silicon nitride 1,000 Å thick was grown on both sides of the wafer by low-pressure chemical vapor deposition. A photoresist was applied and exposed to define windows, which were etched in the nitride by use of a sulfur hexafluoride plasma. The silicon exposed by the windows was etched in aqueous potassium hydroxide to form half-waveguide channels. The rate of etching in the (110) direction (2 μm per minute) was 170 times as fast as in the (111) direction, so that a nearly perpendicular-sided channel resulted. At this rate, the silicon wafer was etched through its full thickness in about 11 hours.

The remaining silicon nitride was removed by hot phosphoric acid, and the silicon channels thus formed were glued with polyimide resin to a 0.05-inch-thick (0.13-cm-thick) flat silicon substrate, making a half-waveguide channel substrate. The substrate was diced into individual half-waveguide channels. To provide the conductive waveguide surfaces, three layers of metal were applied to the channels and top surfaces: 250 Å of chromium and 5,000 Å of gold, both deposited by vacu-



Micromachining a Rectangular Waveguide involves standard steps of masking, etching, and deposition of metal on silicon. The parts thus made are assembled into a half-waveguide and finally into a full waveguide.

um evaporation, then about 3 μm of electroplated gold to provide high conductance for low radio-frequency loss.

The halves were clamped together to form complete waveguides. The measured radio-frequency loss of the waveguides was about 0.05 dB per wavelength over most of the frequency band from 75 to 110 GHz. This compares with 0.024 dB per wavelength for commercial waveguide. The difference of 0.026 dB per wavelength is probably attributable to small defects in the evaporated gold layer that carried through to the plated gold layer. Refinements in the gold-evaporation process are expected to reduce losses.

The silicon-micromachining approach enables the simultaneous fabrication of several versions of a waveguide, with variations in a critical parameter, on a single wafer of silicon. The performances of the versions can be compared and optimized more quickly and at lower cost than is possible if the different versions are fabricated sequentially, by conventional machining techniques.

Most important, active and passive electronic devices can readily be integrated with silicon-based micromachined waveguides. For example, a thin, electromagnetically transparent silicon nitride membrane could be placed in a waveguide, and such components as Schottky diodes, tunnel junctions, and tuning elements could be fabricated directly on the membrane.

This work was done by William R. McGrath, Yu-Chong Tai, and Markus Yap of Caltech and Christopher K. Walker of the University of Arizona for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 83*** *on the TSP Request Card. NPO-18903.*

Hand-Controlled Brazing-Paste Dispenser

Hand control has proven superior to foot control.

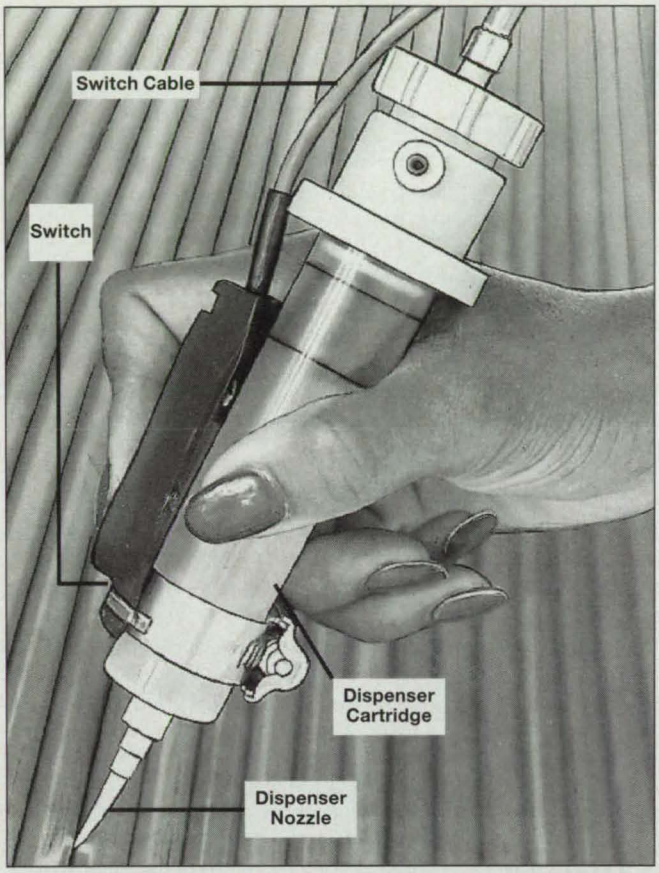
Marshall Space Flight Center, Alabama

A hand-operated switch added to a hand-held brazing-alloy-paste dispenser (see figure) yields improved, more consistent brazing-alloy beads. The dispenser has been used to apply the paste between adjacent tubes in a heat exchanger.

Previously, a technician used a foot switch to control the flow of paste from the dispenser as the technician's hand moved the dispenser nozzle along a recess between adjacent tubes. A precise distribution of paste, suited to the taper of the tubes, is needed for a good braze joint. However, it was difficult to coordinate the foot control with hand motions to coordinate the volume of paste dispensed, along with the position and velocity of the dispenser, to achieve the required distribution of paste. In contrast, the hand switch enables the technician to control the flow of paste and the position and velocity of the dispenser all with one hand: this enhances coordination, providing a more consistent and controlled distribution of paste.

The hand switch is resistance-welded to a small band clamp and wired with small-diameter shielded conductor cable. It is mounted directly on a dispenser by use of the band clamp and plugged into the dispenser control unit in place of the foot switch. The control unit supplies pulses of pressurized air to the dispenser in response to the technician's commands relayed via the hand switch. The switch is reliable and safe, and can be removed and reattached easily, so that cartridges can be interchanged easily.

This work was done by Jeffrey L. Gilbert of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 99*** *on the TSP Request Card. MFS-29910.*



With Just One Hand, a technician controls the flow of brazing-alloy paste from the dispenser. The switch (under the operator's forefinger) controls the flow of compressed air to the dispenser cartridge.

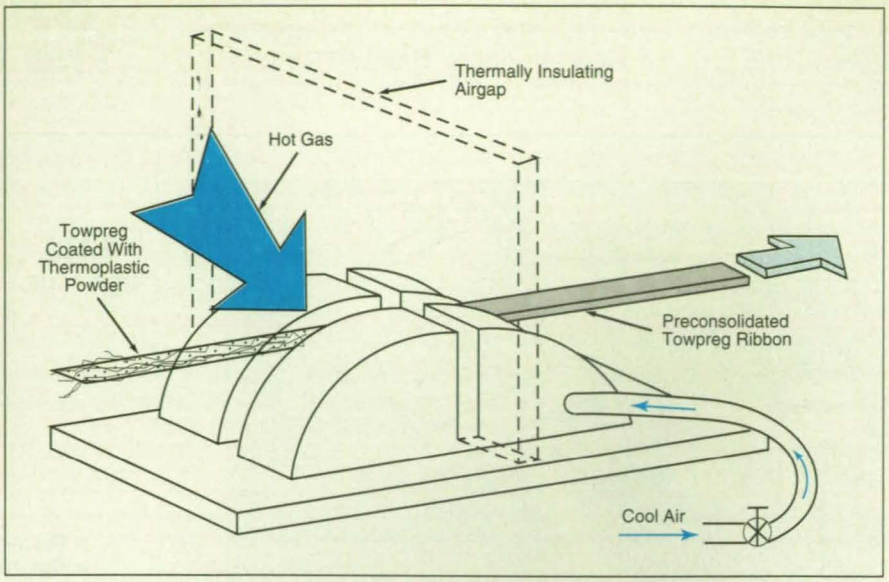
Ceramic Tool for Preconsolidation of Powder-Coated Towpreg

This tool converts partly formed towpreg into preconsolidated towpreg ribbon.

Langley Research Center, Hampton, Virginia

The potential use of various thermoplastics that perform well at high temperatures as matrices in composite materials that also contain carbon fibers has prompted research to identify novel techniques for the production of advanced composite prepreg systems. Many of these thermoplastics cannot be dissolved by environmentally benign solvents. When these polymers melt, they typically exhibit high viscosities and are difficult to use in conventional prepreg operations because they exhibit reduced flow during impregnation. Several techniques have been developed to plasticize these polymers, but the plasticizers tend to reduce the desired mechanical properties of the polymers in their bulk forms.

Research at NASA Langley Research Center has led to the development of a novel prepregging technique and tooling to



The **Ceramic Preconsolidation Tool** includes heated and cooled halves that are thermally insulated from each other.

implement it. In this technique, a towpreg coated with thermoplastic powder is converted into a preconsolidated ribbon without the use of any plasticizers or solvents of any kind. Relying on melt flow and proper application of tension, friction, and cooling, this technique ensures both consistent distribution of the polymer within, and consistent cross section of, the ribbon.

This innovative debulking technique (see figure) draws on the advantages of pulling unidirectional filaments through a heated and cooled open-faced die. The die, called the "ceramic preconsolidation tool," was constructed specifically for this purpose. After the bulky towpreg leaves a payout creel, it is warmed by a flow of hot gas. Initial contact between the melted towpreg and the tool occurs on a curved surface that channels the towpreg into the tool. As the towpreg is drawn through the tool, it spreads out to fill the channel. This accomplishes two things: first, it allows for melt squeeze flow to distribute the polymer more evenly throughout the bundle of fibers that constitutes the towpreg; and second, it facilitates nesting of fibers under tension, thereby promoting debulking. The heated towpreg that leaves the heated half of the tool has the shape of a wide and flat ribbon. A thermally insulating airgap separates the heated half of the tool from the cooled half. The hot ribbon enters the cooled half of the tool and there is cooled to a solid under controlled conditions. Shrinkage of the polymer and its reduced stickiness at the lower temperature allow the ribbon to separate from the surface of the tool on the cooled side.

This work was done by Robert M. Baucom of **Langley Research Center**, *Donald A. Sandusky of the College of William and Mary, and Joseph M. Marchello of Old Dominion University. For further information,* ***write in 79*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14983.

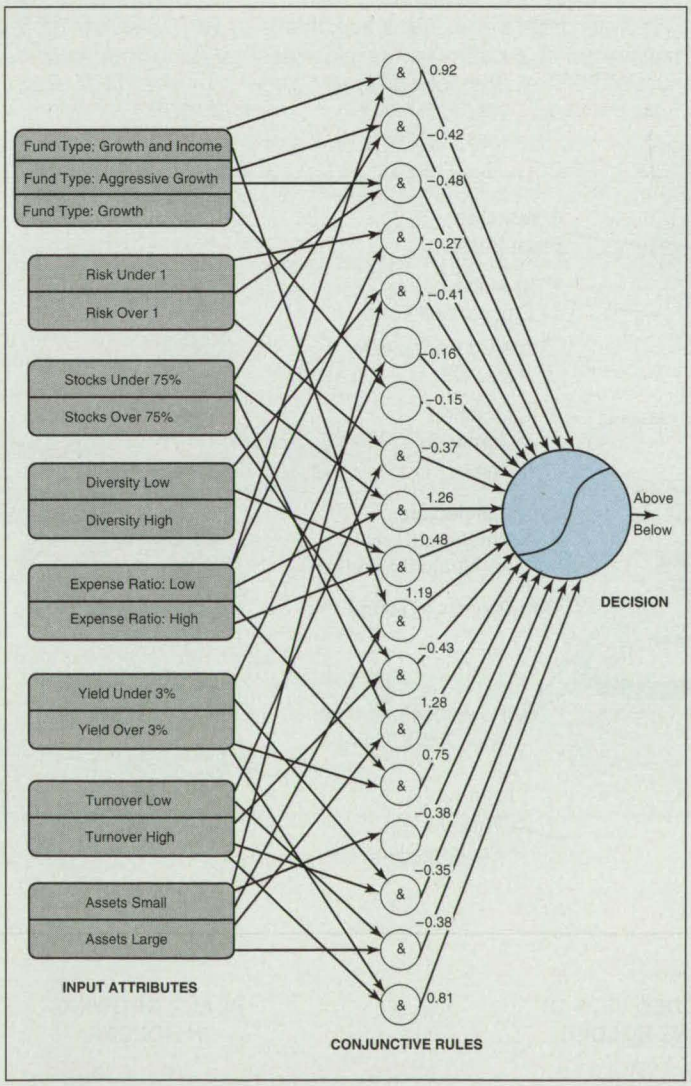
Automated Induction of Rule-Based Neural Networks

Prototype expert systems can be set up quickly.

NASA's Jet Propulsion Laboratory, Pasadena, California

Prototype expert systems that are implemented in software and that are functionally equivalent to neural networks can be set up automatically and placed into operation within minutes by following an information-theoretic approach to the automated acquisition of knowledge from large example data bases. In contrast, the manual approach to the acquisition of expert knowledge involves interviewing human experts and analyzing their responses, so that the construction of a typical expert-system computer program takes months. A prototype expert system created automatically by the novel approach can be used as a sophisticated search and analysis tool to query the original data base, and is capable of reasoning with uncertain and incomplete data.

The novel approach is based largely on the use of the ITRULE computer program, which implements algorithms that search a data base efficiently and which automatically induces probabilistic rules that express relationships among the data. Such a rule is of the following form: If $Y = y$, then $X = x$, with probability p_r and utility U, where X and Y are vectors (attributes) of discrete random variables, x and y are particular values of these variables in the data base, p_r is the rule-transition probability given by the conditional probability $p[X = x \mid Y = y]$, and U is a measure of the informational utility, information content, or "goodness" of the rule.



This **Rule-Based Neural Network** was constructed by the ITRULE process from a table of data on several thousand mutual funds. The output of the network is a prediction of the probability that the 5-year return of a new fund will be above or below the Standard and Poor's market average return.

The rules induced by ITRULE can be loaded into a standard expert-system software shell, wherein the value of U associated with each rule is used to assign a priority to that rule when resolving a conflict between it and another rule. Alternatively, or in addition, the rules can be used to synthesize a parallel-processing probabilistic inference network like a neural network, and this is what is done in the present novel approach. Unlike in the frequently cited concept of a neural network as an implicit "black box" predictor, a neural network constructed by use of ITRULE has an explicit architecture and operation. The architecture is explicit because links in the network correspond to rules. The inference is explicit because the weight on each link corresponds to the "weight of evidence" associated with each rule (see figure). The explicit nature of such a rule-based network also enables humans to audit all its decisions.

The rule-based network is a powerful new extension of a simple first-order Bayesian classifier. The network is capable of acting as a classifier or, much more powerfully, of yielding an estimate of probability or "confidence" for each output decision. This enables a higher-level expert system or a human to make the final decision. The advantage is that situations in which completely unknown inputs are presented can be identified by low confidence on all the outputs. This alerts the system to the fact that more training is necessary or more input attributes are needed to derive rules to handle the new situation.

This work was done by Padhraic J. Smyth and Rodney M. Goodman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 54*** *on the TSP Request Card. NPO-18955.*

Hydroponic Feed With Suction

Placing the nutrient solution under suction appears to increase growth.

John F. Kennedy Space Center, Florida

A hydroponic system circulates nutrient solution around the roots of plants under a partial vacuum while the stems and leaves are exposed to normal atmospheric pressure. Plants that grow in this system are larger than plants grown in a similar hydroponic system with roots exposed to atmospheric pressure. For example, the dry weights of the roots and leaves of bean plants grown with suction were 3 and 1.8 times greater, respectively, than those of similar plants grown without suction. The yield of edible pods was also greater for the plants grown with suction.

Each plant is grown in a 500-mL polypropylene jar (see figure). A screw-on lid with an 8-cm hole in its top presses a polyvinylchloride disk against an O-ring to seal the disk to the mouth of the jar. The disk has openings for inflow and outflow of the nutrient solution and for a plug that holds the stem of the plant.

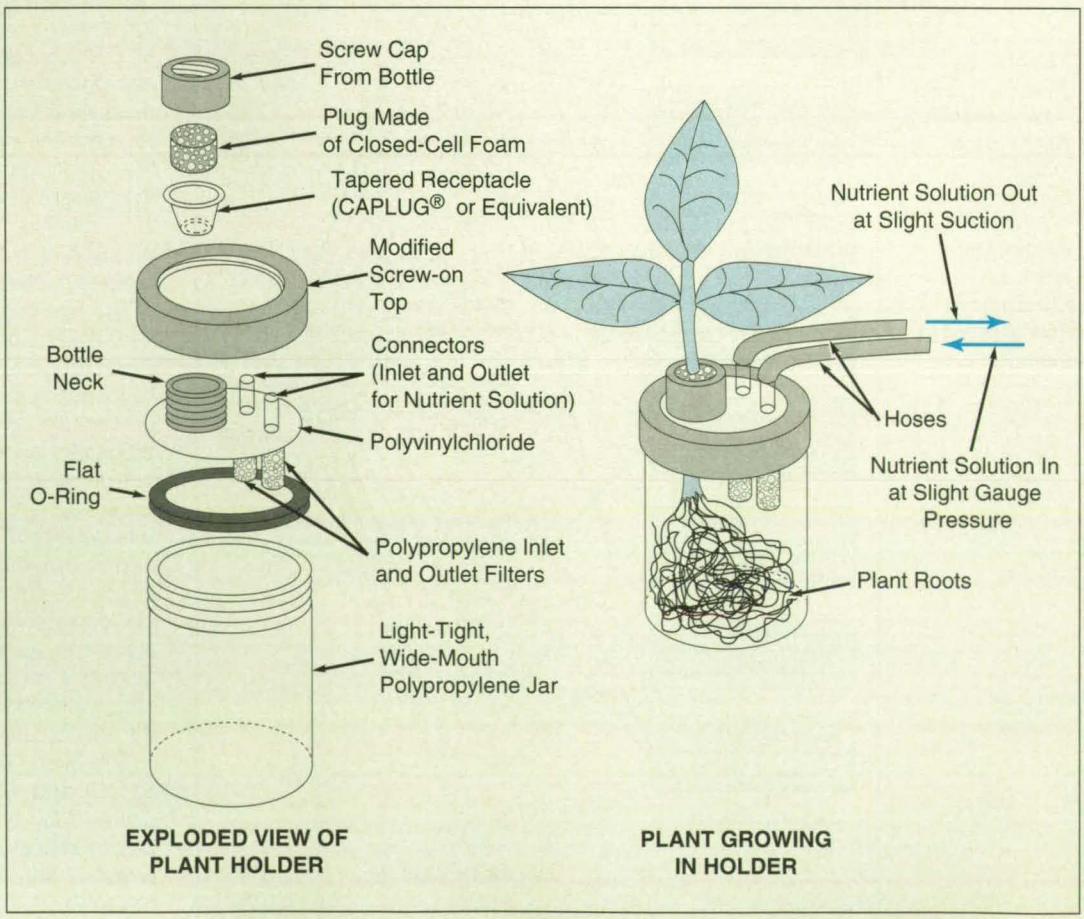
The plug includes a piece of closed-cell foam contained in a tapered receptacle (Caplug® or equivalent). The foam in the plug fits snugly around the stem. The plug allows the stem to expand while providing a seal for the suction on the roots. The plug is held in place by a screw top and the mating threaded neck of a polypropylene bottle.

The solution is supplied to the roots in the jar from a manifold at a pressure of 103.5 kPa (typical atmospheric pressure is 101 kPa). The circulating solution is withdrawn from the jar into a tank that is maintained at a partial vacuum (a pressure of 88 kPa). The solution is recycled from the tank.

The reason for the increased growth of the plants grown with suction is not obvious. The increase has been tentatively attributed to the lower concentration of carbon dioxide in the solution under suction and the enhanced removal, via the suction, of organic compounds (e.g., ethylene) that may inhibit growth of plants. This technology has potential for use in terrestrial applications in arid climates or in labor-intensive agricultural situations (e.g., greenhouse vegetable production).

This work was done by William M. Cox of **Kennedy Space Center** *and Christopher S. Brown and Thomas W. Dreschel of the Bionetics Corp. For further information,* ***write in 33*** *on the TSP Request Card. KSC-11606.*

The **Foam Plug Seals** the growing stem of the plant, making it possible to maintain a suction in the nutrient liquid around the roots. The jar is wrapped in black tape to keep out light.



Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for Aerospace Information.

Physical Sciences

Combustion of Drops of Liquid Fuel in a Vortex

A paper discusses a numerical simulation of unsteady evaporation and combustion of drops of liquid fuel clustered in a vortex. This simulation represents the behavior of drops and the combustion processes that occur in large, coherent vortices in the shear layers of liquid-fuel sprays in air.

This work was done by Floriah G. Fichot, Kenneth G. Harstad, and Josette Bellan of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the paper, "Unsteady Evaporation and Combustion of a Drop Cluster Inside a Vortex,"* ***write in 17*** *on the TSP Request Card. NPO-18973.*

More About Regometer Incremental Probe

A collection of brief documents provides additional information about the device described in "Gauge Measures Hot Erosion of Insulation" (MFS-28651), *NASA Tech Briefs*, Vol. 17, No. 7 (July 1993), page 38. The device is called a "regometer incremental probe." To recapitulate from the noted prior article, the device comprises mainly an array of thermocouples and associated resistors embedded, during manufacture, at preselected depths in insulating material in a solid-rocket-motor blast tube. The device provides an indication of the thickness of the insulation in that its electrical output increases when the erosion front reaches the depth of the outermost remaining thermocouple, putting the hot blast-tube gas in direct contact with that thermocouple. The present collection of documents describes the fabrication and installation of prototype units, presents detailed design information in drawings and text, and presents results of a blast-tube test.

This work was done by Reginald J. Gould of GenCorp AEROJET for **Marshall Space Flight Center**. *To obtain the collection, "Regometer Incremental Probe #3802110-3 & 9,"* ***write in 91*** *on the TSP Request Card.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C 2457(f)], to Gencorp Aerojet. Inquiries concerning licenses for its commercial development should be addressed to: Gencorp Aerojet, ASRM Division; Attn: P. A. Hickok, Contract Manager; 1 NASA Drive; Tuka, MS 38852-8998.

Refer to MFS-28753, volume and number of this NASA Tech Briefs *issue, and the page number.*

Materials

Measuring Thermal Expansion and Contraction

A report surveys methods of measuring the coefficients of thermal expansion of materials. It is meant to be the first in a series of two reports and addresses mainly experimental techniques and data. The second report is expected to discuss theoretical prediction of the thermal-expansion properties of composite materials.

This work was done by Donald Rapp of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "The Dimensional Stability of Materials: Part I — Experimental Methods and Summary of Data,"* ***write in 3*** *on the TSP Request Card. NPO-18984.*

Effect of Preloads On Postimpact Strengths of Composites

A report presents the results of an experimental study of the effect of compressive preload on the compression-after-impact strengths of epoxy-matrix/carbon-fiber composite materials. Previous experimental studies had indicated qualitatively that increasing compressive preloads reduced the ability of composite-material parts to resist relatively light impacts like those from accidentally dropped tools, while at higher impact energies, the amount of compressive preload had little effect on postimpact strength. However, in the more-systematic quantitative study documented in the report, it was found that increasing compressive preloads did not result in statistically significant decreases in postimpact compressive strengths of the composite specimens used.

This work was done by A. T. Nettles and D. G. Lance of **Marshall Space Flight Center**. *Further information may be found in NASA TP-3303 [N93-12678/TB], "The Effects of Compressive Preloads on the Compression-After-Impact Strength of Carbon/Epoxy."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. MFS-27312.

Mechanics

Modeling Progressive Damage in Laminated Composites

A report describes a methodology for predicting the strengths and service lifetimes of structural components made of laminate composite (matrix/fiber) materials. The methodology accounts for the progressive development of microstructural damage in service. Such damage can include intraply cracking of the matrix material, interply delamination, and fracture of fibers, and is a precursor to catastrophic failure during overload.

This work was done by Charles E. Harris of **Langley Research Center** *and David H. Allen and David C. Lo of Texas A&M University. To obtain a copy of the report, "A Mechanics Framework for a Progressive Failure Methodology for Laminated Composites,"* ***write in 2*** *on the TSP Request Card. LAR-14437.*

Solutions of Euler Equations at Low Mach Numbers

A report presents a study of solutions of the Euler equations for two-dimensional flows about airfoils at low mach numbers. The purpose of this study was to assess the accuracy of an Euler computer code and to investigate the factors that affect the solutions. Of particular interest are the effects of the artificial dissipation used to suppress nonphysi-

cal instabilities in the numerical solution, of the clustering of points of the computational grid, and of the mach number on the accuracy of the computed flow field.

This work was done by David W. Zingg of the University of Toronto for **Ames Research Center**. *Further information may be found in NASA TM-102205 [N93-72473/TB], "Low Mach Number Euler Computations."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, User Services Division, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. ARC-12725.

Machinery

Face Gears for Helicopter Transmissions

A NASA technical memorandum describes a theoretical, computational, and experimental study of the potential utility of face gears in lightweight, split-torque helicopter transmissions. Split-torque design is described, and the results of a finite-element structural analysis of a split-torque drive are presented to show that torque can be split evenly when the stiffnesses of shafts that support the gears are chosen appropriately.

This work was done by D. G. Lewicki of the U.S. Army Aviation Systems Command, F. L. Litvin and J.-C. Wang of the University of Illinois at Chicago, R. B. Bossler, Jr., of Lucas Western, Inc., and Y.-J. Chen and G. Heath of McDonnel Douglas Helicopter Co. for **Lewis Research Center**. *Further information may be found in NASA TM-105655 [N92-28434/BR], "Application of Face-Gear Drives in Helicopter Transmissions."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. LEW-15840.

Fabrication Technology

Evaluation of Mathematical Models of VPPA Welding

A report describes a study of three mathematical models of variable-polarity plasma arc welding (VPPAW). The models are based on the physics of the welding process considered at three different levels of abstraction; they predict the widths and heights of weld roots and weld crowns as functions of the properties of the welded metal and parameters of the welding process. The models were developed with a view toward using them in controlling automated VPPAW. The study included experiments on VPPA welding of aluminum and of mild-steel specimens with more than 400 different combinations of welding-process parameters.

This work was done by Kimble D. McCutcheon, Stephen S. Gordon, and Paul A. Thompson of Nichols Research Corp. for **Marshall Space Flight Center**. *To obtain a copy of the report, "VPPA Weld Model Evaluation,"* ***write in 53*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-27289.

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Adaptive Research of Huntsville, Alabama is a leading developer of Computational Fluid Dynamics (CFD) software for simulation of physical processes involving fluid flow and heat transfer. Adaptive was recently acquired by Pacific-Sierra Research Corp. of Santa Monica, enhancing the financial and technical resources of the experienced CFD research and development operation. Following 23 consecutive years of growth and nearly $30 million in revenues in 1993, the new acquisition reaffirms Pacific-Sierra's commitment to expand investment in advanced scientific software products. Pacific-Sierra is healthy, debt-free, and 100% employee owned.

Adaptive's CFD2000® software offers a fully integrated solution for modeling fluid flow, heat transfer, and other physical phenomena. From the intelligent window environment, the analyst can address all aspects of the simulation—including geometry and computational grid, fluid and material properties, initial and boundary conditions, solution monitoring and control, and even 3D field visualization and animation.

Adaptive Research is positioned on the leading edge of CFD technology with new methods utilizing unstructured grid generation and adaptive mesh refinement techniques. Linear tetrahedral elements and automatic remeshing allow for flow calculations over very complex surface shapes and can even compute the associated rigid-body motion dynamics.

In Santa Monica, Pacific-Sierra's Computer Products group is a leading authority on Fortran 90 compiler products, automatic parallelization software for high-speed systems, and superscalar Fortran and C optimization technology. The VAST® System is a suite of software tools that optimize and translate Fortran and C programs on today's superscalar workstations, parallel processors, and mainframe supercomputers.

For more information contact Pacific: Computer Products Group, Pacific-Sierra Research Corp., 2901 28th St., Santa Monica, CA 90405. Tel: 310-314-2300; Fax: 310-314-2323. email: info@psrv.com.

Adaptive Research Division, 4960 Corporation Drive, Suite 100A, Huntsville AL 35805. Tel: 205-830-2620; Fax205-830-2628. email: info@arc-cfd.com

For More Information Write In No. 301

ALGOR

RESEARCH PROVES HEX BEATS TET FOR ACCURACY AND SPEED IN FEA

Most engineers assume that hexahedrons beat tetrahedrons for more accurate and faster finite element analysis (FEA) and a recent study by Algor has confirmed that eight-node hexahedrons are superior to tetrahedrons for accuracy and speed.

Algor's engineers ran FEA tests on a simple beam supported at both ends, with a uniform pressure of 600 square units applied equally across the entire top surface. The beam has a 1x1 cross section and a length of eight units (any system). We generated a number of hexahedral models and tetrahedral models. To generate these models, we used Algor's Hexagen and Hypergen, respectively.

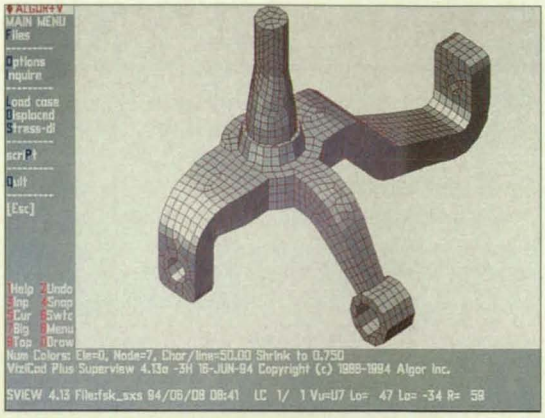
The maximum stress due to bending for this model can be calculated from equations from any number of engineering handbooks. We calculated the maximum tensile and compression stress as 28,800 force/square units.

Our standard was a 1x1 eight-node hexahedral model with eight elements and 36 nodes. We established the run time for this model as one unit of time. The maximum stress was determined to be 27,744 force/square units, a deviation of 3.7 percent. With a 3x3 eight-node hexahedral model with 216 elements and 400 nodes, we improved accuracy to a 0.14 percent deviation, while running time increased to 4.44 time units.

Contrast this extremely precise accuracy with the results from running tetrahedral models: The most accurate results for tetrahedral models were from a 5x5 10-node tetrahedral model with 3,449 elements and 6,440 nodes. This yielded a six percent deviation but had a run time of 602 time units. The fastest run time for tetrahedrons was from a 2x2 four-node tetrahedral model consisting of 462 elements with 169 nodes. Run time was a quick 3.23 time units but this was extremely inaccurate, yielding a 55 percent deviation.

For engineers who want to generate faster, more accurate models for FEA, Algor has introduced **Houdini**—the only interface on the market that will automatically generate a highly accurate quadrilateral surface mesh from a CAD model. Houdini then drives Algor's Hexagen to generate an eight-node hexahedral solid mesh for more accurate and faster finite element analysis.

For More Information Write In No. 302



AMP INCORPORATED

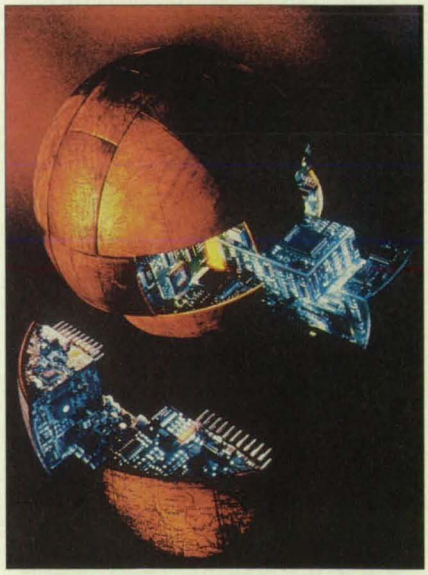
Interconnections have undergone a metamorphosis. Once considered incidental, they are now recognized as integral to the performance of critical systems from aircraft inertial guidance equipment to complex electronics in control communications. No longer simply a means of mechanical attachment, they often incorporate advanced electrical characteristics, miniaturization, and the sophistication necessary to handle various environmental rigors.

As interconnection technology experiences this dynamic evolution, AMP leads the way with research and development in the areas of superconductivity, holography, cold-emission contacts and others that will shape interconnections in the 21st century.

AMP is dedicated to improving customer service. The goal of total customer satisfaction drives such efforts as increased use of cross-functional employee teams and simultaneous engineering to integrate manufacturing, development, logistics and marketing functions.

Broadening service capabilities include a 24-hour facsimile service that automatically responds to dial-in requests for product literature and drawings, electronic application design system discs that enable customer CAD systems to rapidly specify interconnection requirements, and a new approach to packaging based on market needs and customer and distributor requirements.

Behind all efforts to improve responsiveness is the "teaming" approach to supplier/customer relationships, a specific and formal program for customer-driven product development. Teaming coordinates engineering personnel for joint design reviews and other activities, direct resources to solve problems and focuses on quick responsiveness to design and tool products that suit requirements, independent of industry trends.



AMP has the resources needed to make the journey from concept to market—with capabilities far beyond supply to circuit design, analysis, simulation and validation; systems development; and packaging design. All efforts are backed by an unequalled experience with everything from metal and plastic to heavy machinery and precision optics.

AMP is the leading supplier of connectors and interconnection systems, servicing a wide range of markets around the world. The company, which ranks 144th in the Fortune 500 list, employs over 27,000 people in 36 countries and had a record $3.45 billion sales in 1993.

To learn more about AMP, call the Product Information Center at 1-800-522-6752. AMP, Harrisburg, PA 17105.

For More Information Write In No. 303

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ASTRO-MED, INC.

Astro-Med challenged the established beliefs of the recorder industry eight years ago when it introduced the first all-recorder chart recorders with "no moving parts," thus casting aside galvanometric technology that depends on a moving stylus to record data.

Since that time Astro-Med has introduced four generations of its "New Technology" recording systems, each more powerful than its predecessor, and today Astro-Med believes that it is the industry leader. R&D is the key to Astro-Med's success. The company spends 7% of its revenue annually on new product development.

The MT95K2 is a typical example of Astro-Med's wave of revolutionary product development. Not only does it operate with "no moving parts" and record with laser printer resolution, but the recorder permits the user to see the data on a monitor as it is being recorded on chart paper. In addition, the user can program the recorder through a floppy disk as well as store the data internally for subsequent review. These are but a few of the advanced features that have put the K2 in a class by itself.

Recently the Dash IV and Dash 10 portable recorders have joined the New Technology recorder family. Each offers unsurpassed capabilities combined with true portability provided by its internal battery, and both have big, bright, high-response monitors for viewing data and for easy chart setups.

Astro-Med has also extended its technology to other specialty printers. One specialty printer, the Tough Printer, is a ruggedized high-speed printer that supports multiple printer languages such as Postscript and PCL5. The Tough Writer is ideal for use on aircraft test flights, on ships, or in heavy industry.

With its R&D efforts continuing in high gear, Astro-Med has several exciting new graphic recorder products in various stages of development.

Contact: Astro-Med, Inc., Astro-Med Industrial Park, West Warwick, RI 02893. Tel: 800-394-3633; Fax: 401-822-2430.

For More Information Write In No. 304

BLACK & WHITE SOFTWARE

Black & White Software was founded in 1991 to pursue business opportunities in the UNIX and Open Systems marketplace. The emergence of X Windows and OSF/Motif as de facto standards in the Workstation marketplace created a demand for state-of-the-art Graphical User Interface (GUI) development software and qualified professionals, which Black & White moved to address. The initial emphasis was on consulting and training in X Windows, OSF/Motif, and GUIs. A long-term contract with Visual Edge Software expanded Black & White's focus to include UIM/X, the leading GUI builder. In 1992, Black & White became a Value Added Reseller (VAR) for UIM/X with the charter to explore integrations with other market-leading technologies.

Black & White Software is the leading supplier of a wide range of market-leading tools for software development and productivity enhancement including: building graphical user interfaces, building interactive graphics applications, creating front-ends and application connections to databases, and developing client-server applications.

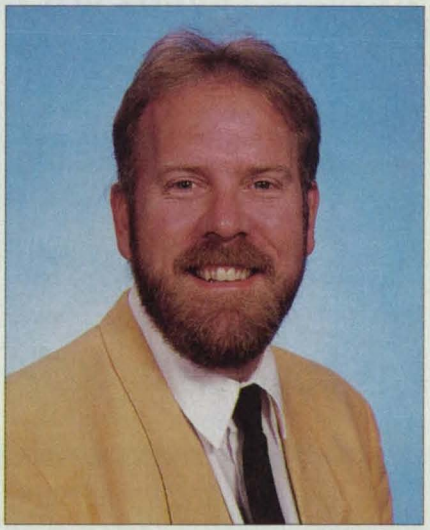
The Black & White corporate strategy is to offer an integrated and interchangeable set of tools for the graphical and client-server application development marketplace backed up by an experienced team of professionals for training, support, and consulting. Black & White products are packaged as individual components, add-ons, or integrated component sets to give developers the option of acquiring the development tools they need as they need them.

Black & White customers include Sun MicroSystems, Lockheed, Boeing, Synoptics, and Martin Marietta.

CORPORATE OFFICERS

Charles White (at right), President and Director of Engineering, began working on Graphical User Interface (GUI) software at McDonnell Douglas Automation in 1980, followed by positions at Daisy Systems and Cadlab in West Germany. A frequent speaker at conferences, Mr. White has been published in numerous conference proceedings and trade journals.

Julia Miller, Director of Business Development, brings to Black and White extensive expertise in data bases, framework, and integration technologies. Prior to Black & White, she held the position of Manager of Open System Software Products in North America for Siemens Nixdorf Engineering Systems. Ms. Miller has published over thirty papers in her field and was recently an invited author for the IEEE Journal.



For More Information Write In No. 305

COLE-PARMER INSTRUMENT COMPANY

Serving the Research and Technical Communities Worldwide

Founded by Jerome J. Cole and John C. Parmer in January 1955, Cole-Parmer Instrument Company has grown from a two-person operation located in a 1200-square-foot loft to a multimillion dollar manufacturer and distributor of scientific instrumentation worldwide. Along with the company's rapid growth, Cole-Parmer is committed to providing outstanding personal service to each and every customer through its comprehensive catalog, knowledgeable Applications Specialists, friendly salespersons, prompt product shipments, and helpful Customer Satisfaction associates.

To meet the increasingly specialized needs of its customers, Cole-Parmer Instrument Company established its own manufacturing division, Barnant Company, in 1957. In addition to providing Cole-Parmer customers with innovative instrumentation, Barnant Company also offers OEM, customer product, and private label services.

Recognizing that technical research takes place around the globe, Cole-Parmer Instrument Company established its own International Sales division, Cole-Parmer International, in 1972. Currently some 60 international dealers market Cole-Parmer products and service to numerous countries, including those in the European Community and the Pacific Rim, in six continents worldwide.

Cole-Parmer customers have come to rely on the company's general catalog as a comprehensive reference for accurate product descriptions and detailed technical information. Cole-Parmer's brand new 1995-96 Catalog, scheduled for distribution beginning in August 1994, continues the company's tradition of offering its customers an ever expanding product selection. This 1736-page, full color catalog presents more than 35,000 products, 4000 of them newly introduced. From its proprietary line of Masterflex® tubing pump systems to sophisticated equipment for biotechnology research, Cole-Parmer strives to help its customers stay on the cutting edge of current technology.

Ongoing projects at Cole-Parmer Instrument Company include a company-wide focus on continuous quality improvement, ISO 9000 registration, and in-house calibration services for many products in the catalog. Cole-Parmer is currently planning to expand its facilities in a new company headquarters to service its customers better.

Both Jerome J. Cole, Chairman of the Board, and John C. Parmer, President, remain involved in all aspects of company operations. John C. Parmer states, "Our positive outlook welcomes challenges in corporate development as we seek to provide many interesting and new products to our customers in the future."

For More Information Write In No. 306

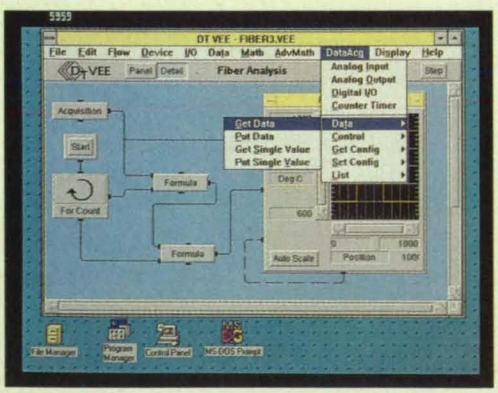
DATA TRANSLATION®

DT-OPEN LAYERS SOFTWARE FOR WINDOWS™MAKES YOUR JOB EASIER

Data Translation's® two newest applications under the DT-Open Layers® standard for Windows™ development offer you unparalleled ease-of-use and productivity gains without compromising power and functionality.

DT VEE™ for Windows is a comprehensive visual programming language that uses icons or objects, instead of text, to develop your data acquisition applications—fast.

Begin with DT VEE's high-level objects that acquire, process, display, and share data. Program intuitively by connecting these objects in a logical sequence. Then run. It's that easy.



DT VEE's objects are intelligent, too. They accept any connection from another object or any data type. Objects are self-labeled for quick identification.

Programs can be changed dynamically—add, replace, or delete objects on-the-fly—for fast debug. Automatic wiring makes connections between objects foolproof—DT VEE won't let you create "bad" wires.

You can expand capabilities by creating user objects that combine DLLs, other DT VEE objects, or your own tried-and-true algorithms. You can create your own objects, too, and reuse your code from application to application.

DT VEE is fully compliant with DT-Open Layers standard. Plus, DT-VEE is based on HP VEE for Windows™, and is backed by the Hewlett-Packard and Data Translation commitment to quality.

GLOBAL LAB Image® 3.0 marks a revolutionary advancement in PC-based scientific image analysis through its new modularity feature. An innovative architecture accommodates Add-In Modules that allow you to easily incorporate a variety of specialized functions into the already feature-rich GLOBAL LAB Image. You will be able to choose from off-the-shelf modules or develop your own.

GLOBAL LAB Image puts an end to compromise. Modularity gives you the ability to add powerful, new capabilities to the easiest-to-use imaging package, while retaining its affordability. In this way, GLOBAL LAB Image will continue to grow with your changing application needs.

This Add-In Module concept—an extension of DT-Open Layers—is offered as a standard for imaging development under Windows. New modules are written as Windows DLLs, and their icons appear as tools in the GLOBAL LAB Image toolbox.

To see DT VEE or GLOBAL LAB Image, call for a free evaluation, at 800-525-8528.

For More Information Write In No. 307

DIGI-KEY CORPORATION

Electronic Components Distributor

Started in 1969, Digi-Key initially sold a telegraphic keyer kit for HAM radio enthusiasts. It was this product from which the Digi-Key name derived. Sales of the keyer were discontinued in 1972 as the company began selling electronic components and accessories to a nationwide market from its single location in Thief River Falls, Minnesota.

With marketing efforts focused primarily on the hobbyist market in its first ten years, Digi-Key showed consistent sales growth. Then in 1982 the company began redirecting its marketing efforts to the industrial user. This positioned the business for continued sales growth. Of the more than 1,500 electronic component distributors in the United States, Digi-Key sales ranked 42nd in 1989, 37th in 1990, 31st in 1991, 27th in 1992, moved up to 25th in 1993, and expects to break the ranks of the top 20 in 1994.

According to the annual "Engineering & Distribution Survey" conducted by *Electronic Engineering Times*, Digi-Key has been the top-rated distributor in the United States in terms of "Overall Performance" the past three years. Results from the most recent survey showed that 90 percent of Digi-Key's customers rated them "excellent." The next closet distributor had a rating of 53 percent.

Digi-Key provides "off-the-shelf" delivery on 95 percent of the tens-of-thousands of items listed in their catalog. This is a "fill rate" that is more than twice the industry average. Digi-Key is also committed to ship all orders entered by 5:00 p.m. central time the same day. Complementing this is Digi-Key's recent ISO 9002 certification for their quality assurance systems, covering the entire order entry-through-shipping process.

"We believe Digi-Key provides the best service in the industry," says Digi-Key president Mark Larson. "With a 30 percent compound annual rate of sales increase for the past 20 years—none as a result of acquisition—I am confident that this rapid rate of sales growth is perhaps the best testimony to the quality Digi-Key consistently provides to it's customers."

Digi-Key recently broke ground for a 170,000 sq. ft. addition, increasing Digi-Key's total facility to approximately 300,000 sq. ft.

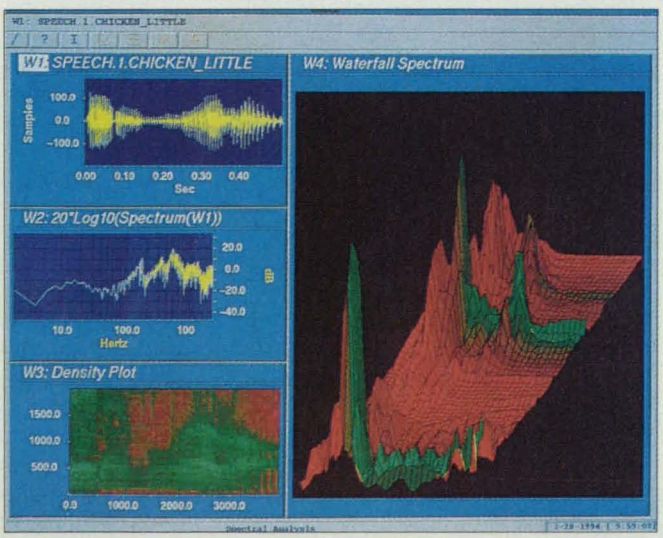
For More Information Write In No. 308

DSP DEVELOPMENT CORPORATION

Data Acquisition, Analysis, and Visualization Software

If your working life is consumed by collecting, analyzing, visualizing, crunching, and reporting on your data, you should be interested in DADiSP. DADiSP is a visually-oriented software package for the display, management, analysis, and presentation of scientific and technical data. If you collect, manipulate, edit, reduce, transform, display, or analyze your data, *and you don't want to have to program*, DADiSP can handle and simplify your data needs. In short, DADiSP improves your day-to-day productivity. Point-and-click operations, icons, buttons, and pop-up menus let you choose from hundreds of functions. *We* could continue describing the product, but read what *customers* say; and them call for a FREE product trial:

- "...able to complete at least 50% more work in the same amount of time..."
- "The ability of DADiSP to provide custom time series data analysis without modifying or writing software makes the program a very powerful tool."



- "Simplicity itself to use. The graphical waveform processor equivalent of a powerful word processor. The use of DADiSP has dramatically decreased the time spent extracting and analyzing data."
- "There is a wealth of built-in functions available...the worksheets and types of analysis possible are virtually unlimited..."

Users in industry, government, and education have successfully applied DADiSP in the following areas: • data analysis • data acquisition and input • scientific visualization • data management • graphics • signal processing • statistical analysis • test and measurement • laboratory automation • experimental hypothesis testing • communications • medical research • image processing • quality management • process monitoring • physiology experiments • noise and vibration analysis • radar and sonar analysis.

Contact: DSP Development Corp., One Kendall Square, Cambridge, MA 02139. Tel: 617-577-1133; Fax: 617-577-8211.

For More Information Write In No. 309

DUPONT ENGINEERING POLYMERS

For cost-effective product design, look to DuPont Engineering Polymers. In choosing alternatives to metals, ceramics or other materials, product designers can gain the dual benefits of high performance and value in use with component parts and resins from DuPont Engineering Polymers.

Fabricated parts

DuPont custom-fabricates "Vespel" polyimide parts and shapes to fulfill needs for ultra-high performance in bearings, insulators and other applications. Key characteristics include: • Continuous operation at 280 °C (550 °F) with excursions to 480 °C (900 °F) • Low wear and friction at high pressures and velocities • Outstanding creep resistance • Lubricated or unlubricated performance • High strength and impact resistance.

To learn more about the benefits of DuPont "Vespel" parts in your application, call 800-972-7252.

Engineering Plastics

DuPont engineering thermoplastic resins offer a combination of mechanical strength, toughness, heat resistance, wear resistance and chemical resistance that sets them apart from general-purpose plastics. A single injection molded component can often replace several metal or thermoset parts. In addition, such parts can be readily assembled using low-cost techniques such as snap fitting or ultra-sonic welding. The bottom line: lower part and assembly costs with equivalent or superior performance, durability and appearance.

Five families of DuPont engineering polymers are available to meet your specific needs:

- NEW "Zenite" liquid crystal polymer resins.
- NEW "Zytel" HTN high temperature nylon resins.
- "Delrin" P acetal resins.
- "Zytel" nylon resins.
- "Minlon" engineering thermoplastic resins.
- "Rynite" thermoplastic polyester resins.
- "Hytrel" engineering thermoplastic elastomers.

To learn more about what DuPont engineering resins can do in your applications, call 800-441-0575.

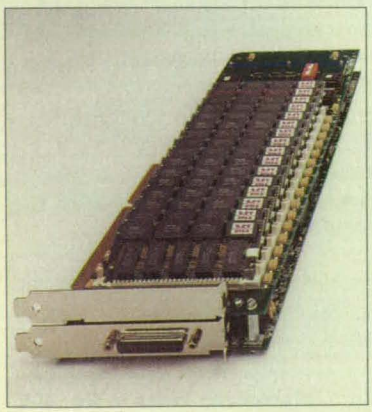
For More Information Write In No. 310

EPIX, INC.

Tomorrow's Imaging Today

EPIX provides state of the art hardware and software to OEMs, system integrators, VARs, and end users in the image processing industry with its flexible image acquisition, processing, and display hardware and supporting software for PC/AT compatible computers.

EPIX imaging boards and software interface to almost any video source including video cameras, recorders, high resolution and/or high frame rate cameras, line scan cameras, medical and graphical displays, etc. User-customizable menu driven image processing software provides morphology, blob analysis, motion analysis, densitometry, measurement, filtering, transforms, archiving, and annotation. DOS and Windows compatible object code libraries are also available, providing comprehensive support for C programmers.



The 4MEG Video Model 12, available with 4, 16, or 64 Mbytes of on-board memory, features programmable memory configurations: high resolutions up to 31,000 pixels per line, or up to 16,000 lines; or lower resolutions for image sequences with over 65,000 frames. Capture and display can be accomplished with up to 50 MHz sampling/display rates using an internal or external pixel clock. The Model 12 also features a 12 MIPS (50 MHz) on-board digital signal processor that performs 12 million instructions per second to provide high-speed image processing.

Together with 4MEG VIDEO Model 12, the **NEW IMAGE MEMORY EXPANSION**, pictured here, allows up to 256 Mbytes of image memory to be added to the Model 12 for real time capture of 872 images, 640 pixels by 480 lines, storing 29 seconds of video at 30 fps! Memory configurations of 4, 8, 12, 16, 32, 48, 64, 128, 192, and 256 Mbytes are available to enhance almost any imaging application. Image memory is upgradable to adapt to expanding applications. All features of the Model 12 are available with addition of the **IMAGE MEMORY EXPANSION** including sequential capture, configurable image buffers, programmable video formats, image display, and on-board processing. The **IMAGE MEMORY EXPANSION** supports all Model 12 camera interfaces operating at data rates between 2 MHz and 30 MHz.

The 4MEG VIDEO Model 10 imaging board offers a 10 MIPS DSP application accelerator, up to 24 MHz sampling/display rate, and up to 4 megabytes of reconfigurable image memory.

The SILICON VIDEO MUX series offers a high resolution single-board frame grabber which can digitize from 6 video sources at 2 to 40 MHz sampling/display rates, with 1 or 4 megabytes of image memory, and programmable video resolution and timing as well as acquisition of standard and nonstandard video.

For More Information Write In No. 311

FREQUENCY ELECTRONICS

Our mission is to design, develop and produce components, systems and services that set the world's standards for excellence and leadership in the precision time and frequency technologies for US defense and space programs, and for commercial and global markets.

For the future: We are committed to sustaining our focus on the precision time and frequency segment of our business, looking particularly to new commercial opportunities as we grow and change, and continuing to be a leader in the markets we serve.

Frequency Electronics Inc. (FEI), the leader in precision time and frequency technologies to support US defense and space programs is now our growth on commercial and global markets. Our unique technologies are opening new opportunities worldwide for FEI. In this connection, we are exploring strategic alliances in the US and overseas.

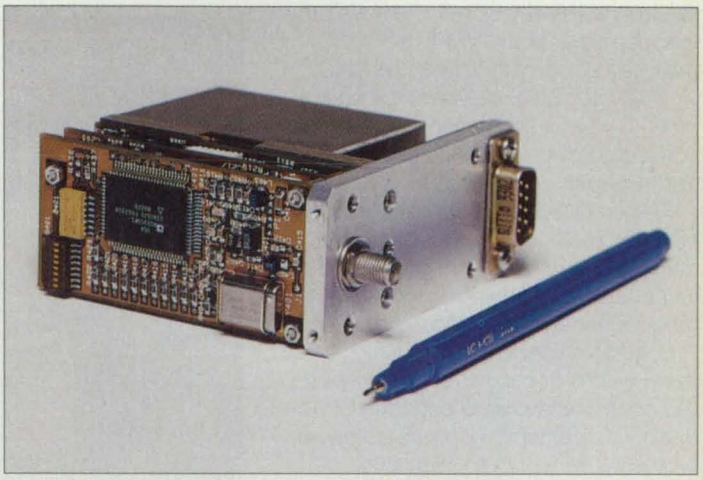
New commercial products that will lead the way for FEI:

• The Commercial Rubidium Atomic Standard is now in its first production run. This new, extremely small atomic standard is attracting more and more attention because of its dependable performance and low base cost as ideally suited for use in advanced cellular communications, wireless telecommunications, and navigation applications.

• The Subminiature Oven Controlled Commercial Quartz Oscillator is a low-cost high performance precision crystal oscillator that is being incorporated into growing numbers of systems for satellite transmission, airborne telephony, and geophysical survey positioning.

• The Very Small Aperture Terminal (VSAT) Transceiver represents a large new market for earth stations transmitting voice and data circuits via satellite. Compared to other competitive units presently on the market, our units are smaller in size, lower in cost, and offer higher reliability. We achieved these results by the effective application of our aerospace experience and technology to this new commercial product.

For More Information Write In No. 312



FEI: Rubidium Atomic Model FE-5650A Standard. Low-cost, for commercial communications systems.

GE PLASTICS

In 1928, GE established a large phenolic compounding plant in Pittsfield, Massachussets. Two years later, it created a separate Plastics department that not only produced resin, but also designed and manufactured molds for the plastics industry. Twenty years later, the Chemical Materials Department was established in Pittsfield and was the site of pioneering research and development efforts that initiated the global leadership GE Plastics currently enjoys.

Today, GE Plastics is the recognized leader in engineering plastics, with over 12,000 employees worldwide and sales of about $5 billion. From its world headquarters in Pittsfield, as well as its European center at Bergen op Zoom, The Netherlands and Pacific operations headquartered in Singapore, GE Plastics is dedicated to exploring new frontiers in plastics conversion technology.

The company has established the world's foremost facility for polymer research and application development at its Pittsfield-based technology center. And, its Living Environments concept house near company headquarters serves as a living laboratory for advanced materials and processes. Other GE Plastics' global components include the Silicones, Superabrasives and Electromaterials businesses.

Leading-edge technologists are right at home in GE Plastics' Living Environment concept house near company headquarters in Pittsfield, Mass. Designed as a living laboratory for advanced materials and processes, the 3,000 sq. ft. dwelling is the proving ground for ongoing innovations in building design, manufacturing and construction.

From the introduction of engineering plastics through decades of advances, GE has remained the industry leader and innovator. Where most suppliers' R&D efforts focus on a single class or family of materials, GE Plastics offers a spectrum of basic chemistries. Around the world, architects, contractors and component manufacturers are capitalizing on GE engineering thermoplastics for performance beyond the capabilities of traditional materials.

GE Plastics' portfolio of engineered materials provide exceptional strength, durability, weather resistance and weight efficiencies, allowing design versatility for multi-functional components and modular assemblies. Combine these benefits with unprecedented economies of production and unmatched program development support and you'll see why GE Plastics sets new standards in performance, speed, and innovation.

For More Information Write In No. 313

GENERAL DEVICES

ENCLOSURES AND SLIDES MEET CRITICAL TECHNICAL REQUIREMENTS FOR DESIGN ENGINEERS

The technology required to develop and manufacture enclosure systems for electronic applications has progressed nearly as fast as the equipment the systems contain.

Forty-year-old General Devices first recognized the necessity for keeping up with components when company founder Herbert Fall, while serving as a World War II Naval officer, pioneered the telescoping slide making "hard" rack-mounted equipment easier to access.

It was too obvious—slide the equipment to you for maintenance instead of completely disconnecting and removing from the rack.

General Devices uses flexible manufacturing methods to produce the basic components of Vent Rak® cabinets and racks. Standard components can be modified for unique applications:

• custom vertical panel openings, panel widths or cabinet depths • specified access and control cutouts • structural reinforcements • special airflow provisions • low or very high level EMI/RFI shielding

RFI/EMI CABINETS

Solving RFI/EMI problems is most effective at the point of origin, but in many cases the solution must be found downstream from the source. General Devices' Vent Rak cabinets provide the required shielding attenuation to meet military or commercial testing applications. Vent Rack cabinets of steel or aluminum act as a barrier between emitter and susceptor of EMF. These enclosures provide shielding by reflecting and absorbing the electromagnetic radiation.

Normally, the shielding effectiveness of a solid conductor barrier (steel or aluminum enclosure welded along all seams) can be significant. However, it is not the limiting factor in achieving high shielding effectiveness. The amount of shielding achievable is controlled by barrier discontinuities such as apertures, seams, cable penetrations and air vents.

Shielding and cooling requirements demand air filters or vent panels that are opaque to EMI but still offer minimum resistance to air flow. Barrier discontinuities and seams are a necessary part of the enclosure design, which is also limited by production limitations, accessability, and maintenance of the equipment to be mounted in the enclosure.

General Devices' enclosures and cabinets meet all military, commercial and consumer specifications governing EMI and RFI.

For More Information Write In No. 314

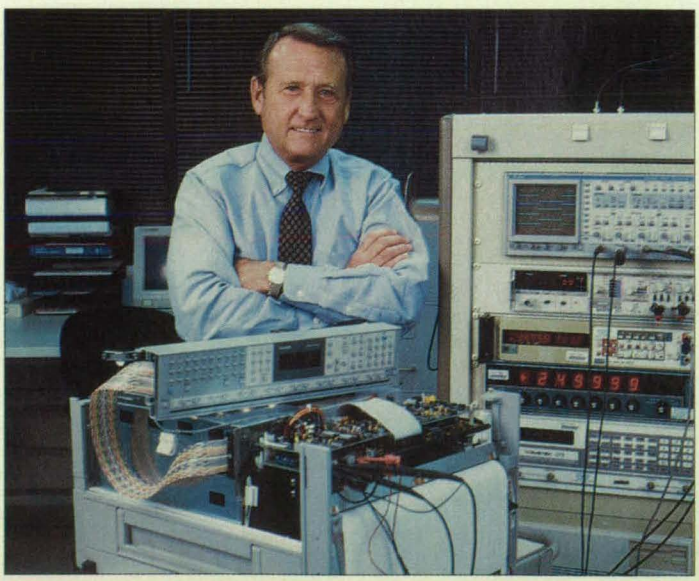
GOULD INSTRUMENT SYSTEMS, INC.

Gould Instrument Systems, Inc. has been manufacturing test and measurement instruments and analysis software for the aerospace industry for more than 60 years. It was a Gould recorder that was used to monitor the first US satellite to reach the moon. Our global sales, application support and service organizations provide on-the-spot support and assistance whenever, and wherever, it's needed.

Gould has been a pioneer in the design and manufacture of high-performance recording instruments, digital storage oscilloscopes, data acquisition systems, signal conditioning and analysis software. According to Edward L. Morrison, President and Chief Executive Officer, "The requirement for success today is based on listening to our customers and understanding their business and challenges. But more importantly, we must independently observe their operations and the way the employees perform their functions. If we do both of these things, we will develop products that solve problems they have today and then avoid problems they probably haven't even thought about."

Test requirements are becoming more sophisticated and more demanding. Therefore, we are developing products with an open architecture that will expand with our customers' test requirements. Today everyone is doing more with less. Tough economic conditions and tougher worldwide competition demand that we make the best use of available resources and design instruments that will help our customers make the most efficient use of their test facilities and their test engineer's time; instruments that combine the functions of several test instruments in a single, integrated product controlled by a simplified graphic user interface.

For More Information Write In No. 315



GOVERNMENT TECHNOLOGY SERVICES, INC. (GTSI)

Uniting Government with Technology

GTSI is the leading reseller of microcomputer and Unix workstation hardware, software and networking products from the largest selection of brand name manufacturers to the federal government market. GTSI specializes in offering a variety of mobile, desktop and engineering workstation computing solutions and cross-platform integration services for DOS/Windows-, Unix-RISC- and Macintosh-based networking solutions. GTSI sells directly and indirectly to all departments and agencies of the federal government, many state and local governments, and hundreds of system integrators and prime contractors that sell to the government market. GTSI provides more than 36,000 products from over 350 manufacturers and is recognized as a true one-stop shop for technology-based solutions. GTSI makes these products available through a variety of important procurement vehicles such as GSA Schedules A and B/C, the Air Force Desktop IV contract, Navy Companion

contract, and the NASA SEWP contract.

GTSI recently announced a series of modification to its NASA SEWP contract, which added more than 10 major products and was essentially transformed into a more diversified ordering vehicle for government customers. New products include technology solutions such as Lotus Notes, Hewlett-Packard printer products, and database platforms, such as Informix, to provide relational database management capability. In addition to all NASA centers, the contract is available to all other government agencies, both defense and civilian, as well as NASA contractors under cost-reimbursement contracts.

With a constant focus on customer services and satisfaction, GTSI sets the standard for, and is the undisputed leader in, providing technology solutions to the government market.

Contact: Deborah M. Tucker, GTSI, V.P. Corp. Communications, 4100 Lafayette Center Drive, Chantilly, VA 22021. Tel: 703-502-2000; Fax: 703-222-5210.

For More Information Write In No. 316

HARRIS COMPUTER SYSTEMS

Harris Computer Systems has been providing quality computer products and services to Government and Commercial markets for than twenty-five years. A technology leader and innovator, Harris introduced the industry's first open architecture, standards-based secure UNIX® multiprocessor systems in 1987, and received the industry's first NCSC B1-level rating of an integrated secure solution in 1993.

Today, the organization is focused in three business areas: Simulation, Data Acquisition and Secure Computing. Harris designs, manufactures, distributes, and supports the Night Hawk® family of high-performance, real-time, multiprocessing computers; real-time and multi-level secure (MLS) UNIX® operating systems and network solutions, real-time software development tools.

Night Hawk computers, the systems of choice for real-time, mission-critical applications such as simulation, integration and test of flight system components, launch support, flight dynamics, command management, schedule and resource management, and flight operations for monitoring and controlling spacecraft and instrumentation, are available to NASA and other government agencies under SEWP Contract #NAS5-37003.

In addition, Harris provides a number of related products, such as NightStar software development tools specifically de-signed for real-time multiprocessing en-vironments, HAPSE and ARMS Ada language support environments, fully integrated Advanced Telemetry Processing Systems, C2, B1, and B2-level Trusted Systems, and migration tools and assistance designed to move existing programs from aging proprietary systems to the open architecture Night Hawk platform.

Contact: Harris Computer Systems, Marketing Communications MS #101, 2101 W. Cypress Creek Road, Ft. Lauderdale, FL 33309. Tel: 305-973-5125 (Marketing Communications); Tel: 305-973-5144 (Sales Support); Fax: 305-977-5580.

For More Information Write In No. 317

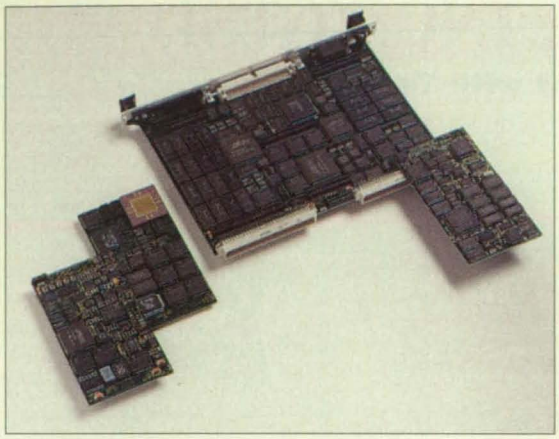
IMAGING TECHNOLOGY INC.

For over a decade, Imaging Technology's products have been used by original equipment manufacturer (OEMs), system integrators and end users who integrate systems to automate processes that replace human vision. These systems solve applications that are tedious, time-consuming, hazardous, or that push the limits of human vision and perception.

Imaging Technology provides modular, open architecture vision processors and advanced software tools that are primarily used to develop high-performance system solutions in three industry segments.

- **Industrial Machine Vision**
- **Scientific and Medical Image Analysis**
- **Aerospace and Defense**

ITI has acquired a unique understanding of machine vision and image processing requirements. Based on this experience, ITI has developed a modular, flexible, open hardware system and software tool set known as the Modular Vision Computer MVC 150/40.



• Modularity

The modular architecture of the MVC 150/40 allows the system designer to purchase only what is required for the specific application. A minimum configuration can be expanded, as necessary, with up to 15 specialized modules.

•Speed

Driven by its 40 MHz pipelined architecture, the MVC 150/40 is the fastest vision processor available today, capable of processing a 512 x 512 image in less than 7.5 milliseconds. Applications not possible with previous vision technology are now easily addressed and applications already using vision technology can be vastly improved by processing more images, and/or analyzing more data per image in less time.

• Camera Interfaces

The MVC 150/40 rapidly interfaces to a wide variety of cameras such as RS170/CCIR, RGB, line scan and large area scan cameras through plug-on acquisition modules and custom cables.

• Comprehensive Software Tools

The MVC 150/40 hardware is supported with comprehensive software libraries that are compatible with DOS, Windows, Sun OS, and Solaris, plus VxWorks and OS/9 real-time operating systems.

• Open System Platform Support

Available in VMEbus and VESA Local Bus versions (with S-bus through a bus translator), the MVC 150/40 is specially designed to work with a variety of host computers and peripherals.

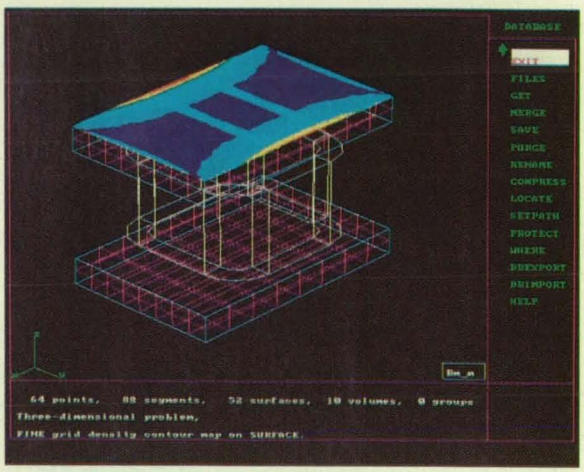
For More Information Write In No. 318

INTEGRATED ENGINEERING SOFTWARE

Integrated Engineering Software congratulates *NASA Tech Briefs* on its 10th anniversary. Integrated specializes in the development of fully integrated Computer-Aided Engineering (CAE) 2D/3D software for electromagnetic design and analysis. All programs are based on the Boundary Element Method (BEM), now recognized as the most powerful field solution algorithm available.

1994 also marks Integrated's 10th year anniversary. In 1984, company founders Dr. Y. Bulent Yildir and Mr. Bruce Klimpke completed their development of a 3D electrostatic field analysis package during their graduate study at the University of Manitoba. This package was sold to US Naval Labs through the University of Manitoba, and proved to be so popular that they were inundated with further requests. The company was incorporated that same year, and established the first sales office in Winnipeg in May 1984.

The first program developed explicitly for commercial use was **ELECTRO** (2D/RS electrostatic) in 1985, followed by **MAGNETO** (2D/RS magnetostatic) in 1987. In 1987 Integrated also established a US office in Ann Arbor, Michigan. **COULOMB** (3D electrostatic) was introduced in 1989. By 1990, the two offices were consolidated into one home office in Winnipeg, where Integrated has remained ever since. **AMPERES** (3D magnetostatic), was produced in 1991, and **Oersted** (2D/RS time harmonic) in 1992. Current projects under development include **KELVIN** (2D/RS heat transfer) and **FARADAY** (3D time harmonic), which are now circulating in beta versions. Integrated software is exclusively distributed in Japan by Sea Corporation, and enjoys a limited distributor arrangement for Europe with Dr. Hans K. Asper of Switzerland.



Company President Dr. Y. Bulent Yildir looks forward to the next ten years: "We intend to continue our tradition of combining quality innovation with superior customer support and service. Since we are so customer-driven, Integrated's customers will be the ones determining our direction in the next decade and beyond. However, we do plan to develop more programs covering a much broader spectrum of engineering applications. I'd also like to say that we are really proud of our achievements over the last 10 years, having helped the most innovative R&D groups in many high technology companies to design more efficient and cost-effective engineering components and equipment."

For More Information Write In No. 319

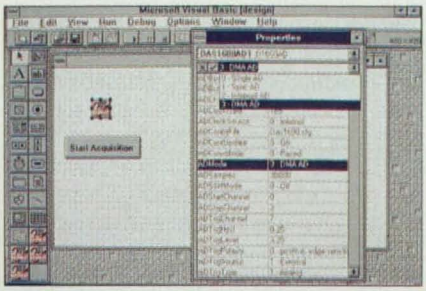
KEITHLEY METRABYTE

Data Acquisition hardware and software

Keithley MetraByte is the world's largest supplier of PC-based data acquisition hardware and software. Its products are sold worldwide to industrial, educational, and scientific-research organizations engaged in laboratory automation, experimentation, process control and data collection applications. The long list of applications range from avionics to zoological research and is limited only by the ingenuity of the engineers who use these products.

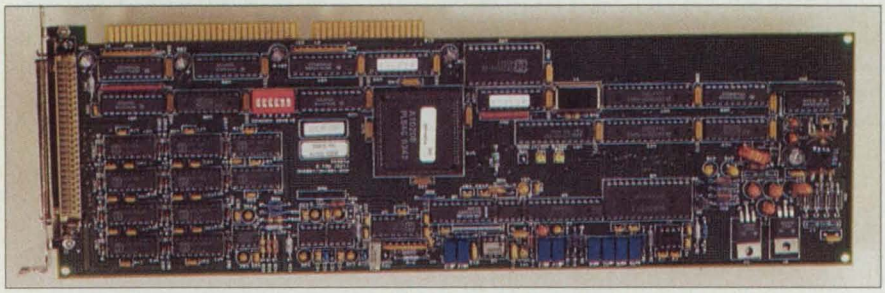
Keithley Metrabyte was the **first** supplier in the field of data acquisition certified as being in compliance with the ISO 9001 standard of the International Standards Organization. It achieved compliance for both hardware and software products.

Examples of the industry-leading products to come from Keithley MetraByte are the VisualDAS software and the DAS-1800 Family of data acquisition boards. VisualDAS is a set of data acquisition custom controls for Microsoft's Visual Basic for Windows. The VisualDAS custom controls simplify data acqusition by replacing large sections of code with simple Windows property boxes.



The DAS-1800 Family is a family of data acquisition optimized for high performance in Windows. All three products in the family feature fast 12 or 16-bit A/D converters, dual channel DMA data transfers, large on-board FIFOs and a gain channel queue. These features allow gap-free data acquisition under DOS or Windows at up to 333 ksamples/second.

For More Information Write In No. 320



VisualDAS custom controls replace large sections of code with simple property boxes. (Top)

The DAS 1800st board is one of Keithley MetraByte's DAS-1800 family of high-speed, high performance data acquisition boards. (Left)

KOLLMORGEN INLAND MOTOR

FAST Drive Digital PWM Servoamplifier

Kollmorgen Inland Motor introduces a digital, PWM servoamplifier for use in high performance motion control applications. The Flexible Amplifier Servo Technology Drive (FAST Drive), can operate a broad range of motors including brush and brushless, permanent magnet, linear, printed disc, and AC induction. Through the use of Digital Signal Processors (DSPs) and Field Programmable Gate Arrays (FPGAs) the FAST Drive is extremely flexible, virtually eliminating changes in hardware for various amplifier configurations. The motor type, pole count, feedback type, and motor phasing are automatically configured by activating the "Auto-Config" input. Advanced features such as loop type, loop compensation, programmable current limit, phase advance, and communication mode are user configurable via the RS-232 serial port.

Two basic mechanical configurations are available, the single board FAST Drive, 1000 watts and the 2-board Fast Drive, 2000 to 6000 watts. The units are packaged in a DIN standard Eurocard, 6U height package. The standard configuration includes a chassis with integral power supply for single-axis applications. Multi-axis applications are ideally suited to the Euro-card packaging. A stand-alone cold plate version will be available soon.

Contact: Kollmorgen Inland Motor, 501 First Street, Radford, VA 24141. Tel: 703-639-9045; Fax: 703-731-4193.

For More Information Write In No. 321

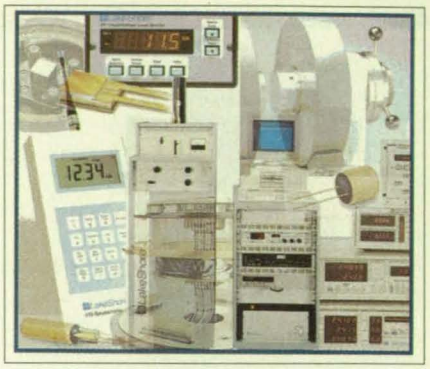
LAKE SHORE CRYOTRONICS, INC.

Nearly three decades of innovation...

Lake Shore Cryotronics, Inc. is an innovator and international leader in the development of world-class measurement and control technology. Since its inception in 1968, Lake Shore has met the technological needs of scientists, researchers, industrial manufacturers and related customers by pioneering the field of low-temperature measurement, and today being recognized as the world's leading supplier of cryogenic temperature sensors. Nearly one half of Lake Shore's employees have technical degrees, many with Masters or PhDs in disciplines spanning engineering, physics or material science.

Continually expanding product portfolio...

Lake Shore's first product was a GaAs diode temperature sensor which was the first cryogenic sensor available commercially to cover the temperature range from 1 to 400 K. This product resulted in the company's first of five R&D 100 Awards for one of the 100 most significant technical developments for a specific year. Additional temperature sensors including Carbon Glass, Rhodium-iron, Platinum Resistance, and Silicon Diode have been specified for such projects as the Space Station, National AeroSpace Plane, and Continuous Electron Beam Accelerator Facility. An introduction of a new family of temperature sensors with low magnetic field dependence resulted from a Department of Energy grant. These sensors provide new options in thermometry for use in materials research. Strategically, Lake Shore has used its sensor technology base to drive growth with complementary component instrument and system products. Foreseeing a growing market for measurement and control of temperature, Lake Shore's product line grew to include temperature thermometers, monitors, controllers, and transmitters. In 1992, the introduction of the 400 series gaussmeters and Hall probes enhanced the successful magnetic measurements group products including AC Susceptometer/DC Magnetometer, true four-quadrant magnet power supplies, and laboratory electromagnets. Lake Shore further strengthens its expanding business base with the systems division



acquisition of the Vibrating Sample Magnetometer (VSM) technology from EG&G Princeton Applied Research. With state-of-the-art, magneto-resistive sensor technology, Lake Shore's newly expanded industrial division manufacturers patented precise position/velocity measurement products for AC/DC motors. Lake Shore is constantly seeking new markets for present technology and acquiring new ideas and patents by license, purchase, or informal associations.

For More Information Write In No. 322

LOCKHEED CORPORATION

Lockheed Corporation, headquarted in Calabasas, California, ranks as one of the largest NASA contractors. The corporation had sales of approximately $13 billion in 1993 and employs about 77,000 people.

Lockheed is a world leader in space system technology with core capabilities in designing and producing satellites, missiles, and launch vehicles, as well as providing a wide range of government and commercial space and engineering services.

Lockheed's principal space divisions are these:

Lockheed Missiles & Space Company Inc. (LMSC) is headquarted in Sunnyvale, California and itself has four operating divisions: Missile Systems and Space Systems in Sunnyvale, Research and Development in Palo Alto, and Austin in Texas.

LMSC has played a significant role in NASA's international space station program since the program's inception in the early 1980s and headed a major effort to automate the design and development of the station's software. LMSC also did the systems engineering, developed the support systems module. and conducted integration and system testing for the Hubble Space Telescope. The company now helps to control the HST from ground station at NASA's Goddard Space Flight Center in Greenbelt, MD. Lockheed supported NASA's first Hubble servicing mission by helping to build service tools and equipment, train the astronauts, and develop mission and operations plans.

Commercial space activities include development of space imaging satellites, a family of new commercial launch vehicles, and space materials development. LMSC will develop the spacecraft bus for the Iridium space-based telecommunications system. LMSC also is part of a consortium with worldwide rights to market launch services for the Russian Proton rocket.

In military space, Lockheed has delivered to the US Air Force the first Milstar communications satellite, which was launched in early 1994.

Lockheed Technical Operations Company (LTOC) based in Sunnyvale, California provides engineering, testing, and training services to the Air Force Space Division.

Lockheed Engineering & Sciences Company (LESC) is headquarted in Houston, TX and provides technical support services to NASA, among other clients.

Lockheed Space Operations Company (LSOC) is headquarted near Kennedy Space Center in Florida and is responsible for all shuttle ground processing tasks as well as the launching and recovery of America's space shuttle fleet.

For More Information Write In No. 323

THE MacNEAL-SCHWENDLER CORP.

The world standard in finite element analysis software

The MacNeal-Schwendler Corporation (MSC) is the leading developer of finite element analysis (FEA) software used in the field of computer-aided engineering. The predictive engineering approach—simulating the performance characteristics of a design before it is built or before a physical prototype is developed—has saved companies hundreds of millions of dollars in research, design, engineering, and manufacturing.

MSC provides 25 percent of the world's software for computer analysis of mechanical designs and is leading industry efforts to expand the market from a current $380 million to a potential market goal of two billion dollars over the next several years. In February, MSC announced plans to introduce during 1994 a new generation of integrated analysis and optimization software packages that will allow even small companies with limited computing power to develop many types of products better, faster, and at a lower cost—with less need for many iterations of costly and time-consuming physical prototypes.

The MSC product line includes our core product, MSC/NASTRAN, a powerful, highly flexible analysis program on an open architecture for analyzing the stress, vibration, and heat transfer characteristics of structures and mechanical components. Besides MSC/NASTRAN, our fully integrated family of predictive engineering products include MSC/ARIES for full-function solid modeling and FEM and FEA pre- and post processing; MSC/EMAS, an electromagnetic analysis system for Electrical Apparatus, EMC, RF & Microwave, and Antenna; MSC/DYTRAN, for solving highly nonlinear, transient dynamic problems; MSC/ABAQUS, for advance material models, special purpose finite elements, user specified routines, and coupled analysis procedures; and MSC/PARTNERS, a collection of software technologies developed by partner companies and provided by MSC to meet specific needs of the design engineering community.

For More Information Write In No. 324

MANUGISTICS STATGRAPHICS Plus for Windows

A New Dimension in Data Analysis

STATGRAPHICS® *Plus* for Windows™ is the easiest-to-learn, easiest-to-use PC-based statistical analysis tool on the market today, giving you instant and easy mastery of the statistical routines you use most. Designed for quality control engineers, statisticians, mathematicians, and others with a need for comprehensive data analysis, STATGRAPHICS *Plus* for Windows combines a broad range of procedures with uniquely interactive graphics.

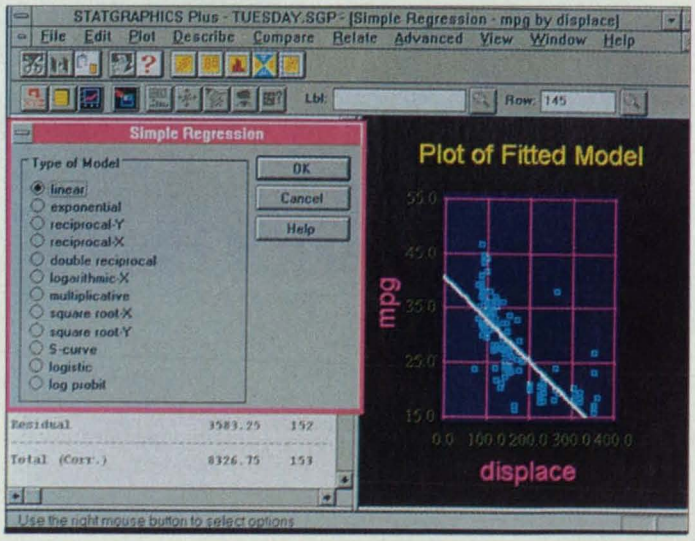
Special features include StatFolio, the revolutionary way to automatically save and reuse your analyses, Dynamic Data Exchange (DDE) support that eliminates the need to import data from a spreadsheet, and interactive graphics inside every procedure that let you fully interrogate data on the screen. Query points on a graph or easily customize your output to include your choice of fonts, colors, and sizes.

The STATGRAPHICS *Plus* for Windows base system gives all of the day-to-day statistical tools you need: regression analysis; ANOVA; one-, two-, and multiple-variable analyses; exploratory data analysis; distribution fitting; crosstabulation; and much more. Then choose whatever additional statistical functionality you need from our array of optional add-on modules including Quality Control, Experimental Design, Time Series, and Multivariate Statistics.

If you've been contemplating a move to Windows for statistical analysis, now's the time. You'll find everything you want in a statistics package in STATGRAPHICS *Plus* for Windows.

Manugistics, Tel: 1-800-592-0050; 301-984-5123 in Maryland; 301-984-5412 from outside the USA or for the name of the dealer.

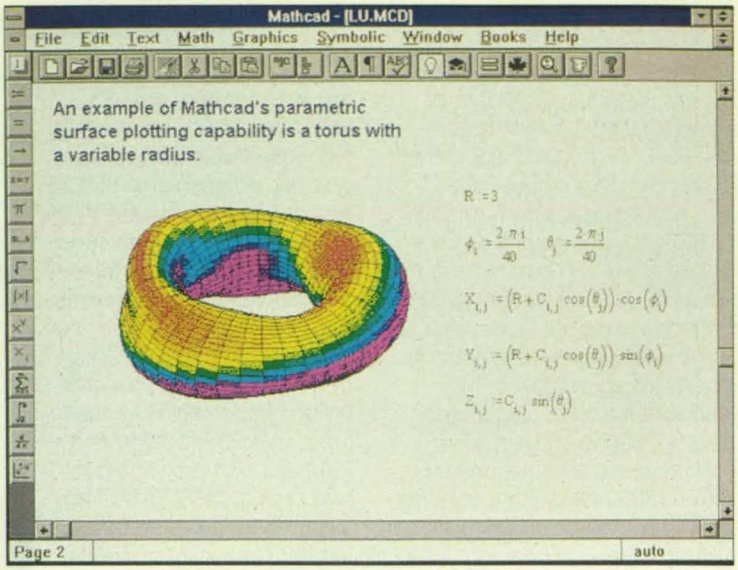
For More Information Write In No. 344



MATHSOFT, INC.

MathSoft develops, markets, and supports general purpose software tools for technical professionals, educators, and students. Its principal product, Mathcad, enables desktop computer users to perform calculations, from the simple to the elaborate, and then document the results. Mathcad provides a "live," easy-to-modify software alternative to scratch pads, whiteboards, calculators, and spreadsheets.

Founded in 1984, MathSoft is the leading provider of technical calculation software for desktop systems. It has shipped more than 500,000 licensed units of Mathcad. Users include technical professionals at more than half the Fortune 1000 companies, 2,000 colleges and high schools, and 450 government and defense installations.



The company acquired StatSci, maker of S-PLUS interactive data analysis and programming software in June 1993. StatSci is located in Seattle, Washington. The new division remains in Seattle and broadens MathSoft's product line and market reach.

Central to MathSoft's product philosophy and its key competitive differentiation, is the company's emphasis on providing easy-to-use software tools for a wide range of technical calculations. While other products focus on specific types of calculations and have complex, command-line user interfaces, Mathcad has a familiar, straightforward interface that enables the product to address universal applications.

MathSoft launched an initial public offering in February 1993 and is publicly traded in the NASDAQ National Market System under the trading symbol "MATH."

For More Information Write In No. 325

THE MATHWORKS, INC.

MATLAB® Technical Computing Environment

Now employing over 200 people, The MathWorks Inc. was founded in 1984 and is located in Natick, MA. The founders of The MathWorks recognized the need among engineers and scientists for more powerful computation environments beyond that represented by procedural languages such as Fortran.

In response to that need, they combined their expertise mathematics, engineering, and computer science to develop MATLAB®, a high-performance technical computing environment that combines comprehensive math and graphics functionality with a powerful high-level language.

The MathWorks has also developed SIMULINK® for simulating nonlinear dynamic systems, Real-Time Workshop™ for real-time C code generation, and an extensive family of add-on products called toolboxes to meet the more specific needs of vertical-market scientific and engineering applications. Over 150,000 technical professionals today use MATLAB to explore, analyze, simulate, design, and solve their most complex and challenging problems.

MATLAB, the underlying numeric computation foundation for all of The MathWorks products, combines hundreds of built-in mathematical functions with powerful 2D and 3D graphing capabilities. In addition, MATLAB offers an underlying programming environment that enables users to create their own functions in a fraction of the time required to write a program in Fortran, Basic, or C. MATLAB offers the convenience of an application package and the flexibility of a language to customize and add new functions as needed. These unique features have made MATLAB the industry standard for technical computing.

MATLAB has found widespread acceptance in diverse application areas where matrix theory plays an important role, such as signal processing, control system design, process identification, image processing, neural network design, and numerical analysis. The MATLAB application toolboxes have been created by renowned experts in their respective fields and represent theory and algorithms at the cutting edge of scientific and engineering research. This solid algorithmic foundation assures maximum efficiency and reliable results.

NASA engineers and scientists nationwide have adopted the MATLAB Technical Computing Environment for several mission critical research and design projects including the next generation High Speed Civil Transport. For researchers who require performance and cannot afford to be limited to "black box" functionality, The MathWorks continues to design and develop products based on an "open architecture." This approach enables users to extend MATLAB for custom applications and to meet their specific requirements.

For More Information Write In No. 326

MAXWELL LABORATORIES, INC.

Maxwell Laboratories, Inc. is a US public company whose stock is traded on the NASDAQ exchange under the symbol MXWL. Maxwell's Maxwell's major products for the pulsed power industry are high energy capacitors, fast acting switches and high voltage power supplies. Maxwell has a staff of about 700 scientific, engineering, and support personnel located mostly in San Diego. Maxwell is a multidivisional company specializing in a variety of products and markets. Besides San Diego, Maxwell operations can also be found in Albuquerque, NM, Carson City, NV, and Washington, DC.

Maxwell Labs was named after James Clerk Maxwell, the Scottish physicist who lived from 1831 to 1879. The crowning work of Maxwell's brilliant mathematical and scientific life was his equations stating that electricity and magnetism do not in isolation. Maxwell's equations of the relationship between an electric field and a magnetic field survived even Einstein's relativity work that upset the world of classical physics. Maxwell Laboratories was founded in 1965 as a scientific and engineering company, specializing in and extending the high technology theories and products that flow from Maxwell's equations. From the start, Maxwell's core business was pulsed power technology based upon the development and manufacture of high energy-density storage capacitors. Over the years, Maxwell products have found their way into markets as diverse as health care, transportation, food processing, metal working, aircraft maintenance, and materials analysis.

In 1992, Maxwell began delivering its highly reliable line of high voltage power supplies. The first models were intended for capacitor charging applications, but the business grew to include automatic cross-over constant voltage power supplies intended to drive arclamps and flashlamps. Today, the Maxwell switching power supply products are used in a wide variety of industrial and medical applications throughout the world.

Recent new product activities arising from our core technology capabilities associated with pulsed power are systems for the cool pasteurization of food products, equipment that uses pulsed light energy for paint and coatings removal and vehicle mounted systems that can perform electric mining.

For More Information Write In No. 327

McDONNELL DOUGLAS

Phantom Works Manufacturing and Prototype Center

Since its inception in May 1991, the Phantom Works has been leading McDonnell Douglas Aerospace efforts in pursuing ways to reduce the cost of producing aircraft and missile systems.

The mission of the Phantom Works is to fundamentally change the way McDonnell Douglas designs, develops, and builds aerospace systems, with the goal of making significant improvements in affordability, while maintaining or improving performance.

The Phantom Works integrated engineering and manufacturing teams apply advanced materials, low-cost tooling concepts, and new production methods to a number of areas: retrofit and modification of production programs; research and development projects; advanced technology demonstrations; and prototype aircraft programs.

Affordability in limited-rate production is a major goal of the Phantom Works, along with low risk and quick insertion of new innovations to the production floor.

The Phantom Works has demonstrated advanced applications of composites, including the feasibility of fabricating large structural components using composite material that cures at low temperatures and reduces the need for expensive autoclaves.

In June 1994, The Phantom Works was awarded a $40.7 million contract from the US Air Force to design and develop a large composite military structure in a military facility using best commercial practices. The structure selected for the 48-month program is a C-17 horizontal stabilizer.

Another area the Phantom Works is pursuing is low-cost tooling technology. The Phantom Works has proven the cost and time efficiencies of producing prototype tooling from inexpensive materials such as fiberglass, wood, plaster, foam, and rubber. For example, in a forward-fuselage demonstration project, prototype tool design and fabrication costs were a fraction of those required for traditional tooling.

Another key area is high speed machining, where aircraft structures, such as wire bundle shelves or landing gear doors, are machined out of aluminum stock by high speed machine tools. This technique greatly reduces the numbers of needed parts and fasteners when compared to traditional methods of building up subassemblies.

The Phantom Works operates with a true concurrent integrated product and process development philosophy by using people, facilities and processes to be innovative, cost-efficient, quick and secure, to give McDonnell Douglas a strong resource with which to capitalize on a changing environment.

For More Information Write In No. 328

MGA SOFTWARE

ACSL Vision Adopts DV-Draw for Simulation Animation

MGA Software and V.I. Corporation, today announced that MGA has selected DV-Draw for integration with MGA's Advanced Continuous Simulation Language (ACSL) software.

ACSL is widely regarded as the standard software environment for modelling dynamic systems in industries such as aerospace, automotive, chemical processing, power plant design, agricultural and pharmaceutical research. DV-Draw™ is the interactive drawing editor in DataViews™, V.I.'s industry-leading real-time animated graphics programming tool.

DV-Draw will be MGA Software's first offering under its *ACSL Video* product family created to enhance the visualization and animation of data developed by the computer simulation techniques that MGA Software can quickly animate system dynamics for improved visualization and analysis, resulting in a more complete understanding of system behavior.

"This is the first of a series of product announcements for visualizing simulation," said Mike Gauthier, President of MGA Software. "The ACSL Vision family will expand considerably in the near future, offering our customers more capability, and more choices for modelling, analysis, and simulation along with data presentation and animation. We chose to incorporate DV-Draw into our ACSL product because it offers extensive animation capabilities that our customers now require to obtain a better understanding of their simulations. Our users need sophisticated features to enhance their designs, but they don't want to spend a lot of time mastering them. DV-Draw's point-and-click functionality will allow for improved model design and analysis without a large investment or substantial learning curve."

The key to successful analysis often lies with the effective presentation, and correlation of multiple data streams (data sets). Animation techniques give the engineer the ability to integrate multiple data streams into a single, dynamic picture. Not only is simulation animation a superb technique for communicating to others, but also the researcher often finds his own insights into subtle system dynamics are significantly enhanced.

ACSL Model, MGA's flagship product, is a general purpose simulation language for mathematically modelling and analyzing the behavior of continuous, nonlinear systems. ACSL helps the design engineer or scientist to simulate a wide variety of dynamic systems.

For More Information Write In No. 329

EXECUTIVE EDUCATION AT THE MIT SLOAN SCHOOL OF MANAGEMENT

In all its program, the Sloan School is committed to educating people to think analytically and act effectively and responsibly in a fast changing environment. Special emphasis is placed on understanding complex systems and on the analytic tools required for estimating opportunities and risks in strategic planning and decision-making. The Sloan School seeks to provide managers with solid awareness of the multiple facets that characterize management problems, from technical data to human and environmental factors. The faculty is committed to excellence in research, teaching and the commitment to be on the cutting edge of management innovations.

The world's first university executive education program was organized at MIT in 1931. The *Alfred P. Sloan Fellows Program*, designed for outstanding mid-career executives sponsored by their organization, is an intensive twelve month master's degree program. In 1956, the *MIT Program for Senior Executives* was initiated. The purpose of the Program for Senior Executives is to improve a manager's capacity to lead in the context of increasing global competitiveness. In 1982 the *MIT Management of Technology Program* was initiated. This program is offered jointly with the School of Engineering and is a twelve-month program leading to the degree of Master of Science in the Management of Technology.

In the addition to its major programs, the School has developed an extensive program of Special Executive Short Courses designed to meet the needs of alumni/ae and other professionals.

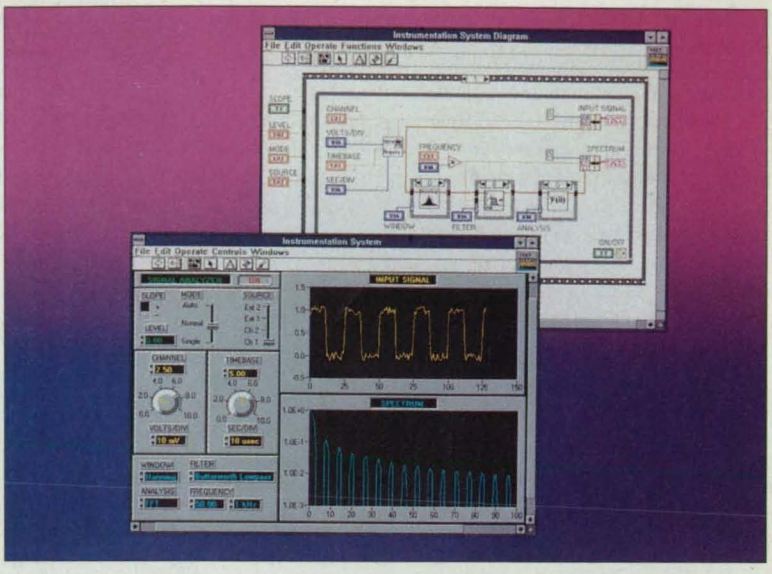
For brochures: 617-253-4432
Tel: 617-253-7166
Fax: 617-258-6002

For More Information Write In No. 330

NATIONAL INSTRUMENTS

National Instruments is leading a revolution in instrumentation—the Virtual Instrumentation Revolution. With virtual instrumentation, personal computers and workstations are combined with software and hardware to build a powerful, but low-cost, instrumentation system. This complete system can consist of all the popular instrumentation alternatives, including plug-in data acquisition (DAQ) boards and GPIB, VXI, and RS-232 instruments.

Founded in 1976, National Instruments today is a leading manufacturer of IEEE-488 interfaces, plug-in DAQ boards, VXIbus controllers, and instrumentation software. National Instruments is dedicated to providing the highest quality products for data acquisition, data analysis, and instrument control. As part of our dedication to quality, last year we announced a new organizational structure that is compatible with the guidelines from the ISO 9000 standards, ensuring that we deliver products and service of unequalled quality to our customers.



All of our products reflect the National Instruments commitment to high quality and innovation at a competitive price. We pledge to continue this commitment to you with investments in research and development that are well beyond industry norms. Likewise, our continued commitment to service will be demonstrated with a growing list of options for customer education and support.

For More Information Write In No. 331

NEW ENGLAND AFFILIATED TECHNOLOGIES

Motion Control and Positioning Systems and Components

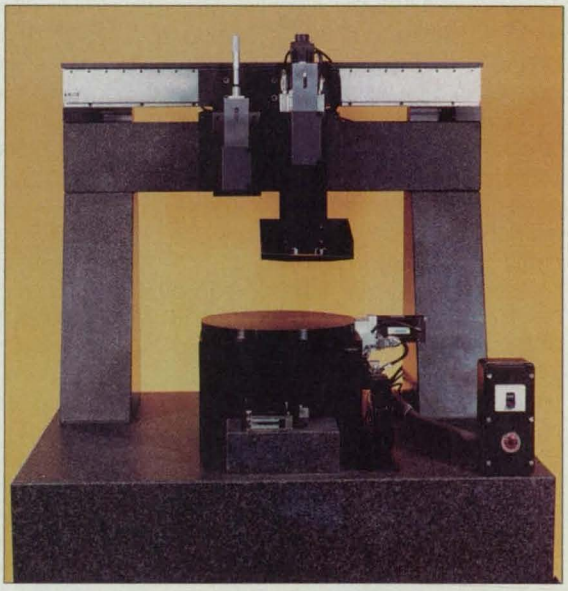
New England Affiliated Technologies (NEAT) is a leading manufacturer of precision positioning and motion control components and systems. Located in Lawrence, Massachusetts, NEAT was established as a division of Instrument Industries, Inc. and has been solving positioning problems for over 20 years.

NEAT operates two, uniquely integrated facilities: a 33,000 square foot building houses the engineering, product design and development, assembly, machining, and administrative teams, while a 13,000 square foot building serves as a Large Systems Facility for the design and production of sizable positioning systems. These tightly integrated teams and facilities allow NEAT to minimize the design and build cycle and respond promptly to customer requirements.

NEAT employs twelve engineers with experience in electronics, mechanics, optics, and physics. In many cases, positioning requirements, whether simple or complex, cannot be met with standard, off-the-shelf components. NEAT's special strength lies in their willingness and ability to provide solutions, not just components.

NEAT prides itself on supplying optimal solutions to challenging customer requirements in fields such as semiconductor inspection and probing, digital imaging, optical bonding, and general automation.

NEAT regularly designs and builds high vacuum positioning systems, and has recently shipped stages that will position a spectrometer aboard ESA's SOHO satellite, to be launched in 1995 into very high (Langrange point) Earth orbit.



Contact: Krista Fabian, NEAT, 620 Essex Street, Lawrence, MA 01841.

Tel: 1-800-227-1066
Fax: 1-800-523-8201

For More Information Write In No. 332

NYE LUBRICANTS INC.

Specialty Lubricants for Mechanical and Electromechanical Devices

Nye Lubricants designs and manufacturers synthetic oils and greases that improve the efficiency and extend the operating life of highly engineered mechanical and electromechanical devices.

Founded as a whale oil enterprise in 1844, Nye began designing synthetic lubricants for OEM applications in the 1960s. The company maintains an extensive lubricant "drug store"—synthetic hydrocarbons, esters, polyglycols, silicones, polyphenyl and fluorinated ethers—and its engineers tap the different technical qualities of these functional fluids to deliver the best solutions to customers' design problems.

This approach to problem solving has made Nye the vendor of choice for many of the world's most innovative component manufacturers. More than 50 Nye oils and greases are written into the specifications of US automobile manufacturers and their component suppliers; two specify only Nye synthetic greases in antilock breaking systems and air bag connectors. In other industries, Nye lubricants are specified in many different products including aerospace bearings, optical instruments, medical instrumentation, telecommunication connectors, electrical controls, appliances and exercise equipment. In addition, leading computer and electronics manufacturers, NASA and the US military regularly turn to Nye for proprietary lubrication research projects.

Beyond their more than 400 synthetic oils and greases, Nye offers a unique array of specialty products, including fluorinated barrier films to control fluid and oil migration, ultraclean lubricants for precision ball bearings, and proprietary index-matching gels that are used as connecting media for fiber optic splices. Nye also maintains the most extensive line of motion control "damping greases," a cost-efficient way to build smooth, controlled, quiet motion into mechanical and electromechanical devices. Electrically conductive greases, sonic coupling fluids, heat sink compounds, vacuum greases and vacuum pump fluids round out their specialty products.

To learn more about Nye products and services, contact Don Fairbanks, Nye Lubricants, P.O. Box 8927, New Bedford, MA 02742-8927; Tel: 1-508-996-6721; Fax: 508-997-5285.

For More Information Write In No. 333

PRESSURE SYSTEMS INC.

From NASA spinoff to industry leader in electronic pressure scanning instrumentation

Pressure Systems Inc. (PSI) was established in 1977 in Hampton, Virginia with the assistance of the Technology Utilization Center at NASA's Langley research facility. As a NASA spinoff, PSI's original charter was to manufacture and market electronic pressure scanning systems to hundreds of aerospace test facilities worldwide. The latest generation of this technology, System 8400, has been used to research the National AeroSpace Plane (NASP), the Advanced Tactical Fighter (ATF), and many other high profile projects. Applications for this instrumentation include wind tunnel model aerodynamic studies, turbine engine performance research and aircraft in-flight testing.

Pressure Systems has received numerous accolades over the years for its achievements. In 1984, PSI was listed in *Inc.* magazine as one of the 500 fastest growing privately held companies. It also has twice been named the Small Business Exporter of the Year for the state of Virginia and, in 1991, was honored with the prestigious President's "E" Award for Excellence in Exporting.

PSI's most recent accomplishment is the successful introduction of its electronic pressure scanning technology to the industrial/commercial sector with the new System 9000. This instrumentation exemplifies PSI's expertise in coupling microprocessor technology to silicon sensor technology to provide state-of-the-art system performance—while keeping the cost affordable. Applications for this instrumentation include testing turbomachinery such as compressors, turbochargers, fans and blowers, as well as other multichannel pressure measurement applications.

The success of Pressure Systems represents a classic case of how NASA technology, combined with vision and entrepreneurship, can be used to benefit many sectors of industry.

For More Information Write In No. 334

RAYTHEON COMPANY

Quincy Operation Microelectronics Center

Raytheon Company's Quincy Operation is the Raytheon outlet to commercial customers that require high reliability microelectronic components and value-added support services for high-end commercial and military applications. Product lines include digital and microwave hybrid microcircuits and Multichip Modules (MCMs), High-Density Power Supplies, Low Temperature Cofired Ceramic (LTCC) substrates and modules, Microwave Integrated Circuits, Surface Acoustic Wave (SAW) Devices, Monolithic Microwave Integrated Circuits (MMIC) Transmit/Receive Modules and Display Devices. Raytheon high reliability hybrid microcircuits are used in heart pacemakers, jet engine control systems, aircraft avionic systems, telecommunications satellites and data communications modules for the US Space Station program. The Raytheon Quincy Facility, Certified and Qualified MIL-STD-1772, includes over 60,000 ft^2 Class 100,000 Clean Room, and complete engineering and environmental test and evaluation equipment. Automated assembly and test support production capacity of over 600,000 hybrid circuit assemblies per year, including an automated production line capable of 4000 devices per month. Raytheon Company, headquartered in Lexington, Massachussetts, is a diversified $9B advanced technology-based company with principal businesses in electronics, appliances, aircraft products, energy and environmental engineering and construction services, and publishing.

For More Information
Write In No. 335

RGB SPECTRUM

VIDEOGRAPHIC PRODUCTS FOR ADVANCED APPLICATIONS

Since its founding in 1986, RGB Spectrum has grown to be a technology leader dedicated to the integration of computer, video, and infrared signals for display and communications. Customers are OEMs, systems integrators, and sophisticated users in industrial, government, and military organizations. Common applications include command-and-control, interactive video disc training, simulation, multimedia display, C3I, videoconferencing, medical imaging, surveillance, remote video monitoring, visualization, robotics, and CAD/CAM.

RGB Spectrum provides an extensive range of products to integrate computer and video signals:

Video Scan Conversion
- Convert computer display signals to video
- Convert medical, FLIR, and radar signals to video
- Convert RGB-parallel to RGB-sequential signals for VR display

Video Windowing
- Display multiple full motion video sources on a workstation screen
- Monitor multiple video signals on a PC, workstation or standalone monitor

Multi-Screen Display
- Display information in a wall-sized format with multiple projection cubes
- Magnify, split, and display computer graphics and video

Image Fusion
- Mix scan converted computer images with video at video resolution
- Mix video, FLIR, or radar signals with computer graphics at high resolution
- Mix two high scan rate computer signals

Video Multiplexing
- Record and playback multiple video signals on a standard VCR RGB Spec-

trum products are offered in both standalone and board-level configurations and are designed for both new installations and retrofits. RGB Spec-trum's philosophy includes a willingness to customize products and direct contact with customers for service and support.

For More Information Write In No. 336

SOUTHCO, INC.

Southco, Inc., designs and manufactures industry's broadest line of latches and access hardware, offering value-added support such as • CAD library files to facilitate your design efforts • factory-trained field sales and engineering service—at your service! • Total Quality Management for consistently high-quality products • fast samples to help in your testing efforts • Southco engineering recommendations to assist you • product modifications and custom design expertise to provide precisely the solutions you want.

Southco has received some of industry's most prestigious awards for quality, which helps recognize our company-wide efforts to meet today's demands for excellence, as well as our commitment to TQM. Southco's systematic, prevention-oriented quality management efforts include:

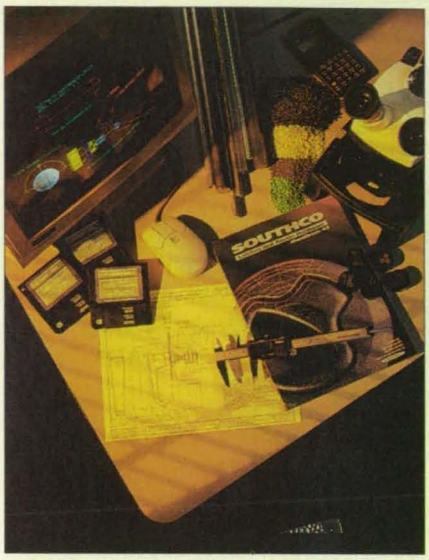
Corporate Quality Council. Top management fosters the importance of quality throughout the entire corporation through this council: giving direction, setting policies and supporting the overall quality program.

Southco Quality Policy Manual. The comprehensive policy manual provides clear direction for the quality system and is supported by procedures and work instructions giving every Southco employee the tools needed to take responsibility for quality.

ISO 9001. An important part of Southco's Quality Program affecting our worldwide customer base includes achieving registration under ISO 9001.

Statistical Process Control. Southco manufacturing processes employ stringent SPC methods to control quality from part-to-part, and batch-to-batch. Each Southco operator, through in-house SPC training, becomes an authority on the process he or she controls.

Failure Mode Effects Analysis (FMEA). These preventive measures are conducted at the design and process stages to determine possible failures and their effects, before any customer buys the product.



Contact: Southco, Inc., Brinton Lake Road, Concordville, PA 19331. Tel: 610-459-4000; Fax: 610-358-6314.

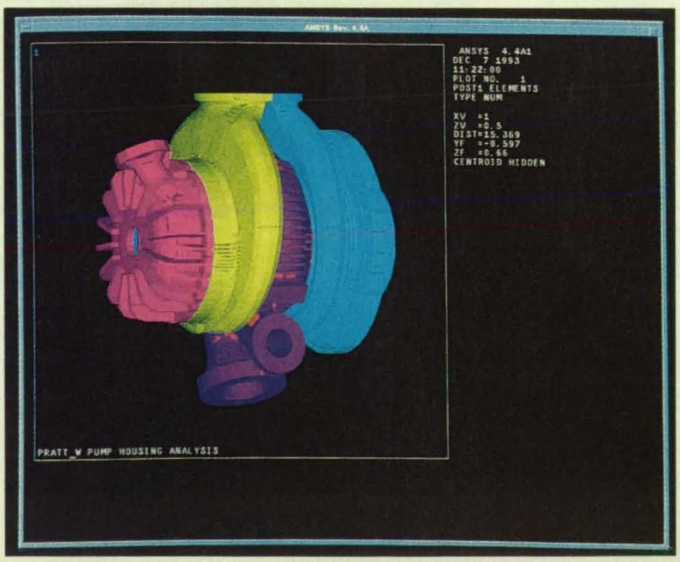
For More Information Write In No. 337

SWANSON ANALYSIS SYSTEMS, INC.

Swanson Analysis Systems, Inc. (SASI), located in Houston, PA, has been a leader in design and analysis software for over 24 years. John Swanson, the company founder and chief technologist, is internationally recognized as an innovator in computer software technology. TA Associates, a large investor in growth companies, recently acquired majority ownership in SASI. Peter Smith, a former top executive with Digital Equipment Corporation, has been named chief executive officer and will lead SASI into its next growth phase.

ANSYS is one of the most widely recognized large-scale programs for finite element analysis (FEA) allowing engineers to construct computer models, apply design criteria, and analyze responses. It is used in a variety of industry applications including aerospace, government, defense, power machinery, biomechanics, and electronics.

ANSYS solves complex design problems because of its powerful capabilities including preprocessing, postprocessing, and design optimization along with structural, thermal, magnetic, fluid flow, coupled field, and nonlinear analyses. ANSYS Revision 5.1, available at the end of September, features a completely redesigned graphical user interface (GUI) focusing in ease of use.



This illustration shows a 3D model of the HPOTP (High Pressure oxidizer turbopump, used on the space shuttle. Engineers at Sverdrup Technology, Marshall Space Flight Center, worked in conjunction with Pratt and Whitney to design an improved turbo pump to replace one built in the 1970s. The different colors represent components or the element type numbering for the different regions of the housing.

Contact: Swanson Analysis Systems, Inc., PO Box 65, Johnson Road, Houston, PA 15342-0065; 1-800-937-3321 or 412-746-3304; Fax: 412-746-9494.

For More Information Write In No. 338

SYNRAD, INC.

Synrad, Inc., the world leader in sealed CO and CO_2 lasers, congratulates *NASA Tech Briefs* on the 10th anniversary of the commercial version of the magazine. This year marks the 10th anniversary for Synrad as well. In the first 10 years, Synrad has grown from being a manufacturer of 10 and 25 watt CO_2 lasers to become the largest manufacturer of sealed CO and CO_2 lasers between 10 and 300 W, as well as offering a full line of electro-optical accessories for lasers with wavelengths ranging from excimer to CO_2.

Synrad, Inc. was founded in 1984 by Peter Laakmann to do advanced research in electro-optics, including gas lasers. Laakman made the RF-excited CO_2 waveguide laser commercially successful in an earlier venture (Laakman Electro-Optics, Inc.). Synrad research and development resulted in a new implementation of radio frequency (RF) excited plasma section that paved the way for higher quality CO_2 and CO sealed off lasers at much lower cost.

Synrad's CO and CO_2 lasers are built using a basic family of modules that are incorporated into all of the power levels, from 10 to 300 W. The plasma discharge section and housing are aluminum extrusion. This patented "all-metal" technology allows for mass production and low costs. Synrad is therefore able to offer superior quality lasers at a fraction of the price of competing lasers.

The competitive advantage enjoyed by Synrad resulted in a growth rate of over 70% in sales in 1993. This favorable growth continues in 1994, in part due to the increasing number of new users of laser technology. Synrad CO and CO_2 lasers are an inexpensive and reliable alternative to existing mechanical tools such as hot knives, dies, routers, blades, milling machines, saws, etc. CO and CO_2 laser applications include cutting, marking, drilling, and heat treating of most non-metals, as well as engraving of anodized aluminum.

Synrad has built upon its reputation of manufacturing the highest quality lasers and now offers competitively priced accessories such as power meter and probes, power controllers, beam delivery equipment, and scanning heads. Earlier this year, Synrad innovation produced the all-new Power Wizard, the first of its kind digital, pocket-sized power meter. Synrad continues its effort to develop unique and affordable laser and electro-optic solutions.

For More Information Write In No. 339

TELEDYNE RELAYS

Once thought to be on the way to extinction, the venerable electromechanical relay is alive and thriving in an ultra-miniature form invented by Teledyne Relays. Today's TO-5 relay is as reliable as a comparable solid state device only far smaller and lower in cost.

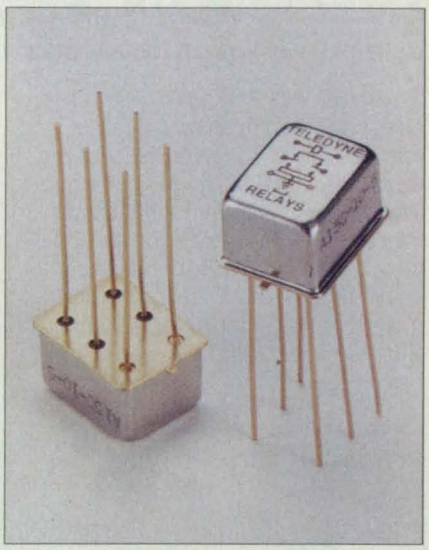
Teledyne Relays is one of the world's largest producers of ultraminiature electromechanical relays. These relays are widely used in applications that include instrumentation, telecommunications, automatic test systems, wireless technology, automotive and medical electronics as well as aerospace.

Teledyne Relays manufactures several types of commercial TO-5 and Centrigrid® relays in a standard line and high sensitivity types that can be actuated by a smaller input power. For a more sensitive response to low signal levels a transistor-driven model is available with the chip inside the relay case.

Electromechanical relays provide a number of advantages in RF switching that are difficult to duplicate with semiconductor devices. Teledyne Relays and its TO-5 and Centrigrid® relay lines have become one of the standards of industry.

Teledyne Relays' current offering includes the A150/153 attenuator relays. These unique relays direct RF signals to an attenuated path or to an unattenuated through path entirely within the relay. There are no other components required.

For More Information Write In No. 340



US AIR FORCE SCIENCE & TECHNOLOGY

The Air Force science and technology program vision is to ensure technology preeminence of US air and space forces. However, many technologies that meet military needs also have utility and application beyond the Air Force. Transferring technology with potential commercial application is part of our mission. Our four Air Force laboratories and basic research organization offer a vast array of technologies available for dual use and technology transfer.

• Armstrong Laboratory, San Antonio TX, provides leadership for new, human-centered technologies, which enable people to do their jobs better, as well as environmental quality research.

• Phillips Laboratory, Albuquerque NM is the focal point for all space and missile related research, as well as geophysics research.

• Rome Laboratory, Rome NY, is the center for command, control communications, and intelligence research.

• Wright Laboratory, Dayton OH, is responsible for aeronautical research ranging from airframe design and avionics to propulsion, materials, and munitions.

• The Air Force Office of Scientific Research, Washington DC, directs the Air Force's entire basic research program in 40 major research areas.

To help industry and academia gain access to Air Force technology, we have recently opened an information "hotline." TECH CONNECT at 1-800-203-6451 provides customers with immediate access to AF technology information and serves as a "one-stop" focal point to connect government and industry to the appropriate Air Force expert.

For More Information Write In No. 341

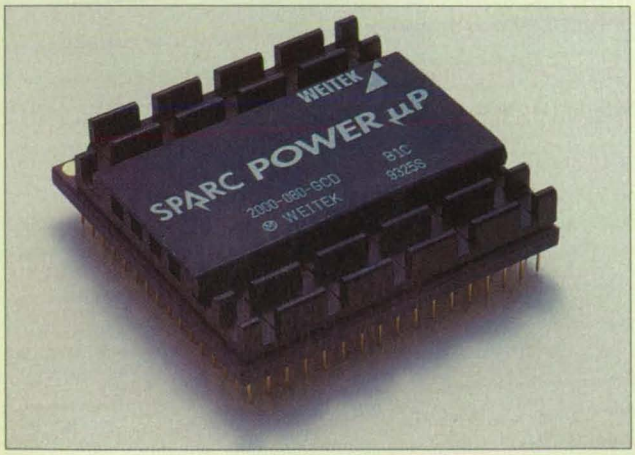
WEITEK

SPARC POWER™ uP doubles the processor power of your SPARCstation and speeds up applications by 1.4x-1.9x

The SPARC POWER™ uP is a single-chip, socket compatible processor upgrade for your SPARCstation 2 and SPARCstation IPX. Using clock-doubling technology similar to that used in Intel's i486DX2™ processing, the 80 MHz SPARC POWER uP brings state-of-the-art processor technology to the more than a quarter-million 40 MHz SPARCstation 2 and IPX machines in use worldwide.

In addition to having the highest clock speed of any SPARC processor, the 1.8 million transitor SPARC POWER uP uses two on-chip caches and Weitek's patented floating-point technology to give the highest possible system performance.

Certified by SPARC International to be SPARC Compliant and backed by all the benefits of Sun-Service's SunSpectrum™ maintenance, the SPARC POWER uP is enjoyed by over 15,000 users. The SPARC POWER uP is completely compatible with the processor it replaces; no drivers or software changes are required and installation takes first time users 15-30 minutes. The SPARC POWER uP is available with a complete installation kit for $1200 or $995 for the chip alone. Weitek can be reached at **1-800-758-7000** or send email to **cpu_upgrade@weitek.COM.**



Features

- 80 MHz clock-doubled processor doubles peak integer performance
- Advanced floating-point unit increases peak performance 2.4x
- 16 KB of code cache, 8 KB data cache —quadruples peak data bandwidth.
- 100% compatible with SPARCstation 2 and IPX processors
- Certified SPARC Compliant by SPARC International
- Approved by SunService: no impact on service contracts.

Benchmark Reality

- 32.2 SPECint92
- 31.1 SPECfp92
- 80 peak MIPS
- 33.3 peak MFLOPS
- Applications show a speedup of 1.4x to 1.9x

For More Information Write In No. 342

WOLFRAM RESEARCH INC.

Engineers, Researchers, and Educators Get Instant Answers to Real Problems through the Internet

MathSource, an electronic resource that makes answers accessible to millions of Internet users, free of charge, was created by Wolfram Research as a service to technical professionals. Wolfram Research is the company behind Mathematica, today's leading technical software for numerical, symbolic, and graphical computation.

MathSource makes a large collection of Mathematica application packages, notebooks, research papers, technical newsletters, and book supplements freely available to the entire Internet community. Over 1700 separate files have been submitted to MathSource by both Wolfram Research staff and by enthusiastic Mathematica users. Each week, MathSource is accessed more than 4,000 times by more than 2,000 people.

SOME POPULAR *MATHSOURCE* ITEMS

0202-240	Signal Processing Packages and Notebooks V. 2.9.5
0204-523	Exploring Neural Networks with *Mathematica*
0202-419	Notebooks to Accompany Microeconomics Analysis
0202-611	COSY-PAK: A Symbolic Analysis Package V. 0.9
0202-183	Lyon's Cochlear Model
0204-679	Animating Schroedinger's Equation in Two Dimensions
0202-385	FeynCalc 1.0: A Package for Feynman Diagram Calculation

MathSource is accessible through electronic mail on all major computer networks, as well as through anonymous FTP, Gopher, World Wide Web (WWW), and direct dial-up. To begin using *MathSource*, send e-mail containing the single-line message `Help Intro` to mathsource@wri.com. For further information on *MathSource*, contact ms-admin@wri.com, or call Wolfram Research at 800-441-MATH.

Contact: Mark Moline, MathSource Administrator, Wolfram Research, Inc.; Tel: 1-800-441-MATH; Fax: 217-398-0747.

For More Information Write In No. 343

COMBO-D

Coax, High Voltage, Power & Signal Contacts Crimp and Solder

20 Contact Combination Variants Available Within Shell Sizes 1, 2, 3, 4, 5 & 6

CONTACTS: Machined copper alloy, gold over nickel plating. Coaxial, High Voltage and Power contacts removable. Power contacts 10 to 40 amp. rated. Signal contacts 5 amp. rated. **TERMINATIONS:** Signal and power: solder, crimp, printed board, straight or 90°. **INSULATOR:** Polyester glass U.L. 94V-0. **SHELLS:** Steel, zinc, cadmium or tin plated, stainless steel. **MOUNTING:** Panel and printed board. **COUPLING:** Jackscrew and slide lock system. **HOODS:** Metal, plastic. **CRIMPING MACHINES:** High speed, automatic strip and crimp machines. **NORMS:** Conform to IEC 807-2 and MIL-C-24308. U.L. and CSA recognized.

POSITRONIC INDUSTRIES, INC.

423 No. Campbell Ave. • P.O. Box 8247 • Springfield, Mo. 65801 **800-641-4054**
Tel. 417-866-2322 • Telex 436445 • Fax 417-866-4115

For More Information Write In No. 410

New on the Market

Digiplan Division of Parker Hannifin Corp., Harrison City, PA, has introduced the DS Series of high-power **brushless servomotors** for powers ranging from 1.8 to 10 hp. Users can select from a choice of five drive modules and seven 3-phase 8-pole motors. Different combinations provide continuous torque outputs from 26 to 220 in.-lbs., with a peak capacity in excess of 500 in.-lbs. and speeds up to 4000 rpm.

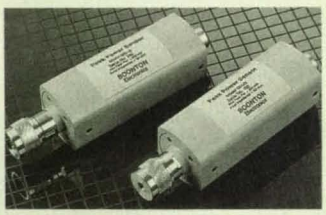
For More Information Write In No. 713

Prescon™ **pressure-sensitive sensors** from International Microelectronics Research Corp., Tucson, AZ, can measure pressures as low as one gram with high sensitivity, convert physical pressure to the electrical response of ohms, and offer activation thresholds as low as .002 lbs. pressure. They are suitable for polymer thick-film membrane switches and sensors, industrial control and measurement systems, and medical instrumentation.

For More Information Write In No. 714

The Nano, a **miniature six-axis force/torque sensor** from Assurance Technologies Inc., Garner, NC, was developed for use in robotic, medical, and manufacturing applications such as prosthetic device testing, physical rehabilitation, robotic hand research, and automotive part testing. Measuring 17 mm in diameter and 14.5 mm thick, the device can be calibrated to measure up to 12 lb./4 lb.-in. Stainless steel monolithic construction insures high overload protection.

For More Information Write In No. 703

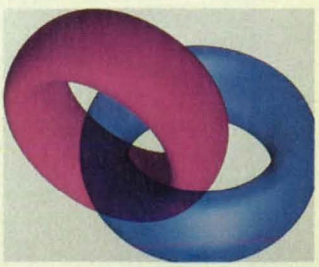


Boonton Electronics Corp., Randolph, NJ, has announced the Model 56518 **peak power sensor** for measuring digital wireless systems. When used with Boonton's Model 4500 digital sampling power analyzer and Model 4400 power meter, the sensor provides power density distribution statistics to precisely characterize the transmission performance of digital cellular, radar, and avionics systems.

For More Information Write In No. 719

Visual Numerics Inc., Houston, TX, has released **Windows NT versions of its IMSL C numerical libraries and IMSL exponent graphics**. These 32-bit libraries support Intel-based PCs running Microsoft's Visual C++ compiler under Windows NT. The new libraries are aimed at developers familiar with IMSL tools on mainframes or workstations who want to downsize, as well as PC-based C programmers who can save time by embedding the prepackaged mathematical and statistical subroutines and 2D and 3D technical graphs directly into their C applications.

For More Information Write In No. 702



Neural-network speech recognition integrated circuits from Sensory Circuits Inc., San Jose, CA, sell for as little as $3.25 in volume. The line includes the RSC 164 and 264, each of which provides more than 40 seconds of on-chip speech or sound effects and can recognize hundreds of words, broken up into 2-to-10-word sets. The 164 can address off-chip ROM for large-vocabulary applications.

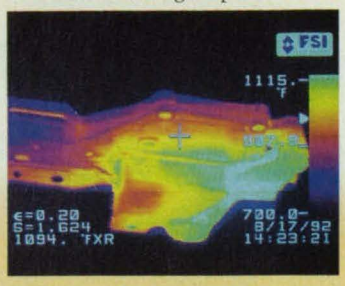
For More Information Write In No. 711

Integrated Motions Inc., Berkeley, CA, has released the first commercial **robot system** with integrated force control capabilities. The Zebra ZERO Force Control Robot features a six-axis force/torque sensor used to monitor end effector forces. An integrated hybrid force/position servomotor controls these forces to precise, programmable values. The unit is controlled by an 80386/80387-based IBM PC and programmed in the C language.

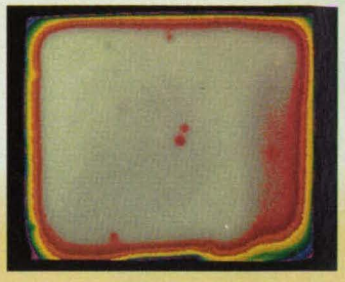
For More Information Write In No. 717

Engine development

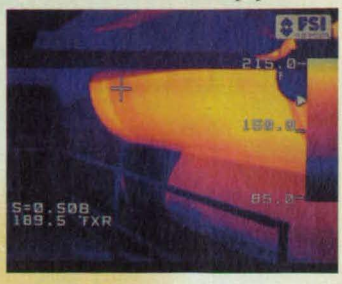
Measure casting temperatures



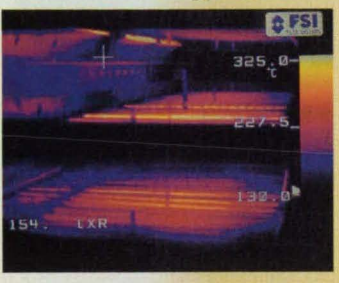
Defects in composite materials



Moisture content in paper

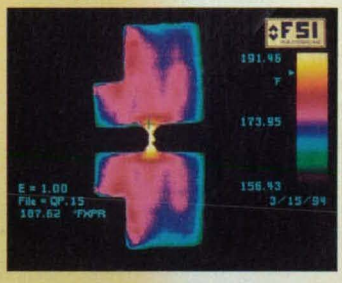


Monitor soldering processes

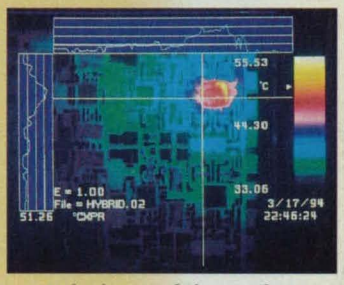


FLIR SYSTEMS POINTS OUT YOUR DEFECTS WITH WARMTH AND SENSITIVITY.

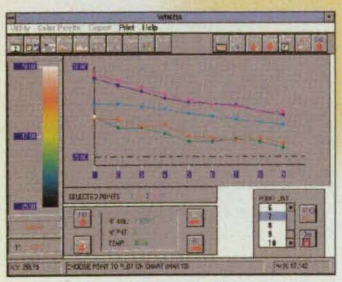
Injection mold performance



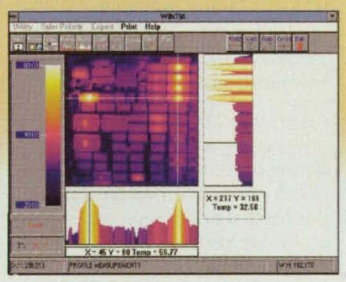
Evaluate wax injection presses



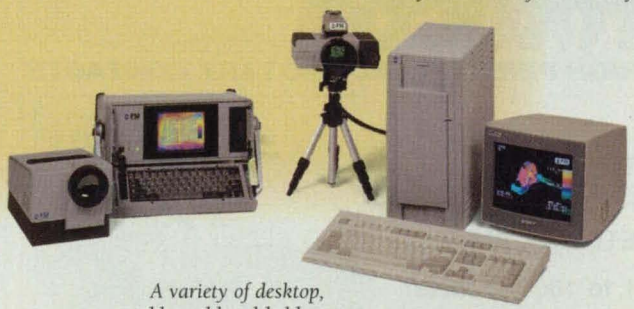
Hybrid circuit failure analysis



Analyze trend data



Post-processing thermal analysis



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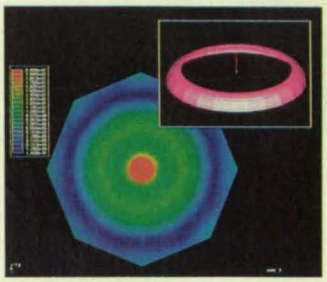
For More Information Write In No. 696

New on the Market

IBM Microelectronics, Fishkill, NY, has announced the industry's fastest "lossless" **data compression chip**. Capable of processing as many as 40 MB/sec., better than most PC buses, the Adaptive Lossless Data Compression (ALDC) device performs data compression in real time without reducing system performance. It supports multiprotocol DMA data and standard microprocessor interfaces, as well as 8- and 16-bit selectable data buses with selective parity checking, external peripheral access, 16-byte first-in first-out buffer, and bypass modes.
For More Information Write In No. 707

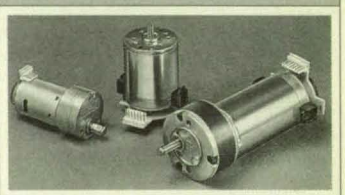
VideoLabs Inc., Minneapolis, MN, has introduced FlexCam Scientific™, a variant of the FlexCam™ **desktop video camera**. The standard 8-mm C-mount lens can image objects precisely, including x-rays, for display on monitors or computer frame-grabbers. The lens may be focused down to 1 in., producing microscopic magnification of 50:1 when viewed on a 25-in. monitor.
For More Information Write In No. 701

Cline Labs Inc., Phoenix, AZ, has unveiled an **electronic clinometer**, an angle-measuring sensor that uses fluid as the active medium. Offering the highest performance/cost ratio in the industry, according to the manufacturer, the device has no moving parts, provides a dc voltage proportional to the rotation angle, and makes possible electronic angle measurement in industries where it had been impractical. The base plate and cover are molded of a lightweight, reinforced thermoplastic that encloses the surface-mounted sensor and CMOS electronics.
For More Information Write In No. 704



Ansoft Corp., Pittsburgh, PA, has released version 3.0 of Maxwell® SI Eminence, a suite of solvers including AWE-FEM designed to model **electromagnetic interference and compatibility**. The program's full-wave/radiative electromagnetic simulator can model radiation from ground planes and power/signal nets, emissions from cables and chassis, and FM circuit models for very-high-speed components.
For More Information Write In No. 708

Compact Air Products, Westminster, SC, has announced a **manifold actuator** that reduces by half the space required for a computer hard-drive testing station. The assembly's oversized cylinder block allows integration of flow controls, ports, and valves, eliminates two air lines and four fittings per station, and reduces assembly time by 40 percent.
For More Information Write In No. 705



A **Hall effect encoder** from Merkle-Korff Industries Inc., Des Plaines, IL, employs incremental, digital pulse technology to provide positioning and velocity data. Features include one channel design; one, two, and four pulses per revolution; 5-24 Vdc supply voltage, 100 kHz maximum count frequency, and -40 to +50 °C operating range.
For More Information Write In No. 715

Pegasus™, an **interactive in-system logic emulator** from ARKOS Design Inc., Scotts Valley, CA, enables prototyping of ASICs, ASSPs, microprocessors, video chips, and other complex digital devices before going to silicon, increasing the odds that first-pass devices will work properly. Pegasus has a built-in logic analyzer, instant access to all nodes, and fast design compilation times. It accepts netlists generated from schematics or hardware description languages, and will emulate complex devices at speeds of 3-15 MHz.
For More Information Write In No. 700

New on the Market

The six-axis SC15 **general purpose robot** from Nachi Robotics, Novi, MI, offers the fastest available axis speed in the 15-kg load-capacity class, according to the manufacturer. Designed to provide access to "tight spots," the robot's streamlined design routes all hoses, air and coolant lines, and cables internally. Other features include a small, rigid, in-line wrist and position repeatability to 0.1 mm.

For More Information Write In No. 709

Touch Memories, a line of **computer-memory chips packaged in 16-mm steel buttons** that read or write at a touch, has been announced by Dallas Semiconductor, Dallas, TX. The company has supplied the US Postal Service with silicon labels bearing the memories for installation directly on collection mailboxes to monitor on-time delivery. The miniature databases can be updated while the chip is affixed to a mailbox or other station.

For More Information Write In No. 712

The VAMP II **flat panel display** from Computer Dynamics, Greer, SC, is the first 262,000-color TFT LCD and touchscreen that can be driven directly from a PC. The VAMP II plugs directly into any standard VGA analog output and can handle graphics-intensive programs, such as multimedia with full-motion video, previously available only with a CRT. Infrared, NEMA 4/12, and capacitive touchscreens are optional.

For More Information Write In No. 720

Eastern Air Devices Inc., Dover, NH, has introduced the first **linear actuator** designed to operate where lubricants cannot be tolerated. Featuring a rotor shaft made of DuPont® Vespel® polyimide that never needs lubrication, the actuator is a bi-directional dc stepping motor with 1.8° per step.

For More Information Write In No. 716

An **investment casting material** formulated by Precision Metalsmiths Inc., Cleveland, OH, offers qualities previously unattainable in solid mold casting of low-temperature, non-ferrous alloys. Called NC-178, the material reduces thermal shock and mold cracking, distortion of mold cavities, and core failure—all of which contribute to casting rejects and scrap. NC-178 offers uniform thermal expansion when heated to casting temperatures and will not settle away from patterns after investing to leave unfilled mold areas or deformed castings.

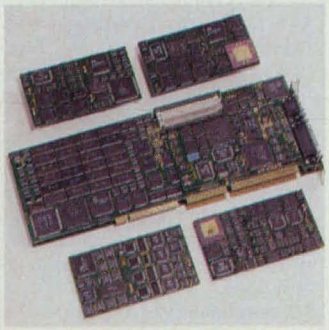
For More Information Write In No. 718

SOLUTIONS Software Corp., Enterprise, FL, is publishing the complete *TSCA Chemical Inventory* of more than 61,000 substances. Available on a CD-ROM from the Department of Commerce's National Technical Information Service, the database includes every chemical that is manufactured or imported into the US. Chemicals are indexed by CAS number and name, common name, molecular formula, and synonym.

For More Information Write In No. 706

Imaging Technology Inc., Bedford, MA, has unveiled the Modular Vision Computer, a highly scalable and configurable **vision system** for VMEbus and PC VLbus host computers. Driven by a 40-MHz pipelined architecture, the MVC 150/40 can process a 512x512-pixel image in less than 7.5 ms.

For More Information Write In No. 710



New Literature

Cambridge Electronics Laboratories, Somerville, MA, has published *Black Magic! Telecom Design Tricks*, a collection of advanced design principles and practices for **telecommunications power, ringing, and ISDN circuits**, including 20 "cookbook" schematics. Appendices list technical references and vendors of unusual or little-known components employed in the schematics.
For More Information Write In No. 732

A 24-page brochure from Tol-O-Matic Inc., Hamel, MN, highlights the BC2 Series™ **rodless pneumatic band cylinders**. Designed for use in all types of automation, the units feature a patented load-bearing carrier system that isolates the piston from the load, a spring-loaded dust band insertion ramp that compensates for wear in high-velocity applications, and a machined magnet slot in the carrier bracket for field retrofitting of switch sensors.
For More Information Write In No. 727

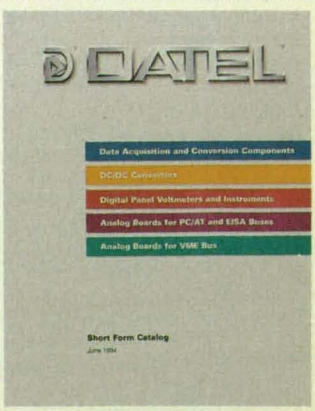
A 40-page **microwave circuit design** guide published by the Soladyne Division of Rogers Corp., San Diego, CA, provides fabrication guidelines for multilayer, microstrip, and stripline circuits. Topics include material selection, machined features, patterning, PTFE activation, metallization, design for manufacturability, and quality assurance.
For More Information Write In No. 723

A broad range of **heat dissipation components and accessories** for electronics applications are detailed in a catalog from Wakefield Engineering Inc., Wakefield, MA. Products include integrated circuit cooling heat sinks, aluminum extrusion profiles and custom fabrications, board-level power semiconductor heat sinks, precision compression clamp systems, and liquid cool plates. Thermally-conductive compounds, adhesives, mounting hardware, and installation tools also are described.
For More Information Write In No. 724

Farrand Controls, a division of Ruhle Companies Inc., Valhalla, NY, has released a brochure describing its rotary and linear Inductosyn® **position transducers**. Featuring accuracies to better then ±40 microinches and ±0.5 arc second, the transducers perform well in extreme environments such as cryogenic chambers and at high temperatures, vacuums, and hydraulic pressures.
For More Information Write In No. 721

An application report released by General Magnaplate Inc., Linden, NJ, describes how MAGNAPLATE HMF®, a **coating for metal parts**, can solve problems affecting robotic systems used in manufacturing. The coating's micro-smooth finish, with a hardness rating of up to Rc 68 and coefficient of friction as low as .06, greatly reduces wear. By providing a film of dry lubricity, it reduces drag, while its uniform, dense finish resists attack from both ambient humidity and abrasive materials.
For More Information Write In No. 725

A 64-page short form catalog from DATEL Inc., Mansfield, MA, spotlights **data acquisition and conversion components** up to 16 bits and 20 MHz, modular switching dc/dc converters up to 50 W, 3½ and 4½ LED and LCD digital panel voltmeters, and analog computer boards for PC/AT, EISA, and VME buses.
For More Information Write In No. 722



New Literature

A brochure from Soft-Noze™ USA Inc., Utica, NY, highlights the SOFT-NOZE line of cushioned **sensor mounts** to fit all sizes and brands of proximity sensors. The mounts' spring-loaded design renders sensors immune to impact failures upon overtravel: the sensor simply retracts into the SOFT-NOZE housing to avoid damage. Each kit also includes a protective plastic cap to prevent abrasion of the sensing face.

For More Information Write In No. 733

Adjustable speed drives, right angle gear drives, and linear actuators are described in a catalog from Zero-Max Inc., Minneapolis, MN. Featured products include five sizes of adjustable speed drive offering a constant torque of 12 to 200 inch pounds throughout their speed range, right angle gear drives in 1:1 and 2:1 speed ratios and two- and three-way versions, and five sizes of Roh'lix® linear actuators.

For More Information Write In No. 730

The Resistor Handbook, published by CJ Publishing, Olathe, KS, combines resistor theory with practical circuit application information. Chapters address resistor fundamentals; composition; film, wirewound, and nonwirewound resistor types; NTC and PTC thermistors; current shunts; and current sensors.

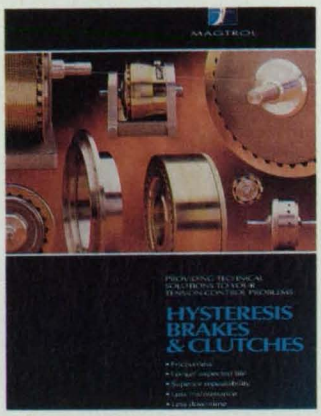
For More Information Write In No. 734

Pneumatic end effectors designed to give manufacturers an alternative to conventional multi-fingered claws and vacuum cups are showcased in a brochure from Firestone Industrial Products Co., Carmel, IN. The devices enable robotic and mechanical pick-and-place systems to handle especially delicate products firmly, yet gently. AirPickers®, which are inserted into a product and then inflated, and AirGrippers™, which surround the product with an inflatable sleeve, employ even inflation for shock absorption and rubber for slip-free contact surfaces.

For More Information Write In No. 728

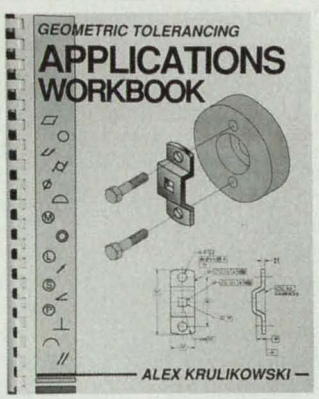
A 212-page catalog entitled *The World of Electronic Materials* is available from Electrical Insulation Suppliers Inc., Hillside, IL. The publication features products for **electronic manufacturing and repair**, static control, soldering, printed circuit boards, EMI/RFI shielding, thermal management, adhesives and coatings, wire harnesses, tubing, sleeving, and insulating.

For More Information Write In No. 731



Magtrol Inc., Buffalo, NY, has published a 24-page catalog of its frictionless **hysteresis brakes and clutches**, which offer smooth torque, high repeatability, and long life for applications in armature and coil winding, printing and labeling, and wire making. The brakes provide calibrated match tension regardless of the number of brakes used.

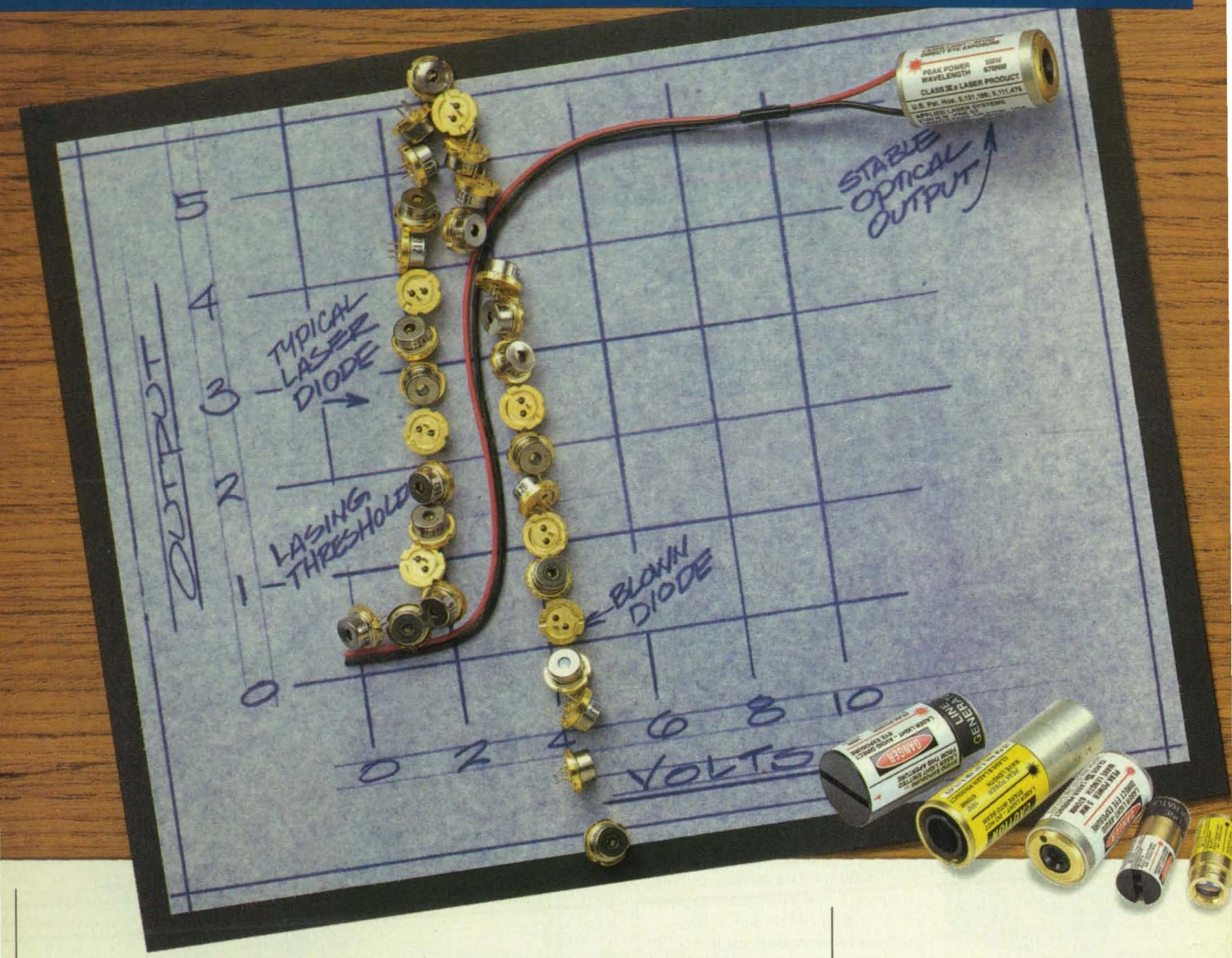
For More Information Write In No. 729



An advanced **geometric dimensioning and tolerancing** applications workbook is available from Effective Training Inc., Westland, MI. The publication, from the author of the *Fundamentals of Geometric Tolerancing Self-Study Workbook*, addresses using charts and decision diagrams to guide dimensioning, recognizing and avoiding dimensioning traps, calculating tolerance values, and understanding the functional dimensioning philosophy.

For More Information Write In No. 726

What Goes Up, Usually Comes Down...



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...the laser diode destined for your product application is completely protected against the forces of electro-static discharge, temperature and handling abuse. That's because a raw laser diode is a fragile and highly volatile device with extreme threshold behavior that will quickly "blow up" under unstable environmental conditions. The typical laser diode is capable of turning on in "one millionth" of a second...and one very short "mistake" usually results in total destruction, rendering the laser diode useless. Applied Laser Systems (ALS) has solved this problem and makes the laser diode usable in the real world.

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And with a field failure rate of less than 1 percent, Applied Laser Systems supports its products with a full ***two year warranty,*** *setting the industry standard. In addition, a small green LED indicator is mounted on the rear of each module to indicate when the laser is operating...a safety factor that ALS alone provides.*

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High-Tech Product News

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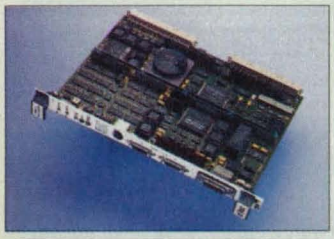

Don't miss the November issue of High-Tech Product News

Call Wayne Pierce at 800-944-NASA

Multiple Hot Cathode Sensor Gauge Introduced

HPS announces the release of the new SensaVac® Series 929 Hot Cathode Combination Gauge. The user configured 929 measures pressure from 10^{-11} to 10^{4} Torr, displaying the measurements of up to five sensors simultaneously.

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HPS manufactures VacuComp™ vacuum components or valves and SensaVac® vacuum gauges. For more information contact HPS at 800-345-1967 or 303-449-9861. **Write In No. 694**

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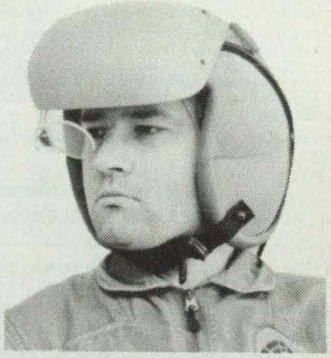

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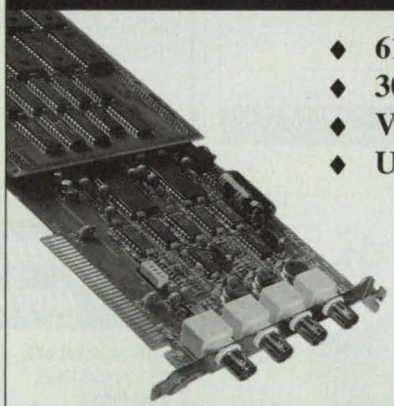

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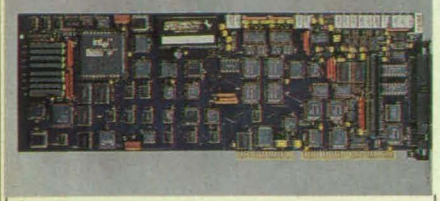
Intelligent Data Acquisition



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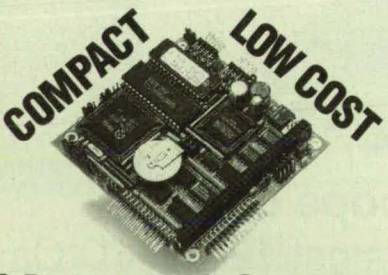

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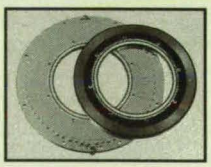

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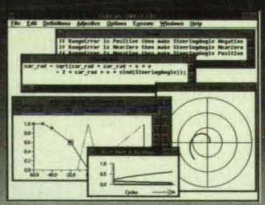

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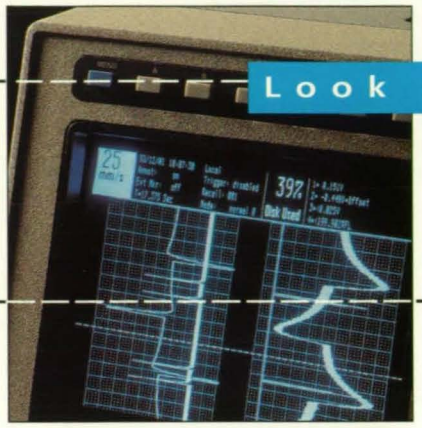
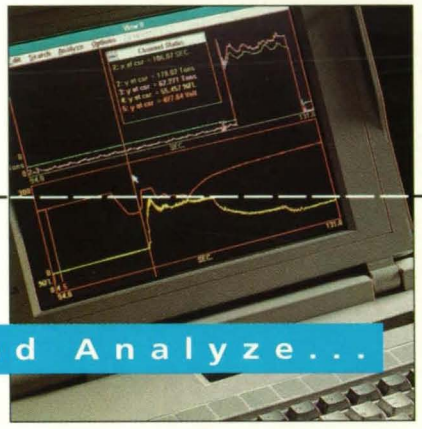
If you want to. . .

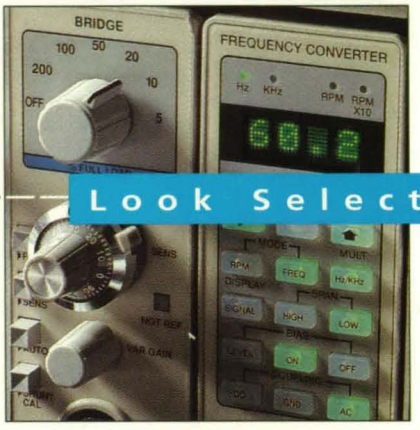
Look Later. . .



Look Now. . .



Look and Analyze. . .



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